UCRL-AR-132057-06-4

**Environmental Protection Department**
**Operations and Regulatory Affairs Division**

# Lawrence Livermore National Laboratory Experimental Test Site 300

## Compliance Monitoring Program for the CERCLA-Closed Pit 6 Landfill

## Annual Report 2006

*Authors*

**Chris G. Campbell**
**Michael J. Taffet**

**Lawrence Livermore National Laboratory**
**University of California, Livermore, California 94551**

**This work was performed under the auspices of the U.S. Department of Energy by the University of California, Lawrence Livermore National Laboratory under contract No. W-7405-Eng-48.**

# Contents



# Figures

## Appendices



## Tables

# LLNL Experimental Test Site 300

# Compliance Monitoring Program for the CERCLA-Closed Pit 6 Landfill

# Annual Report 2006


## Summary

This combined fourth quarter/annual monitoring report is required by the *Post-Closure Plan for the Pit 6 Landfill Operable Unit, Lawrence Livermore National Laboratory Site 300* (Ferry *et al.* 1998). It summarizes post-closure compliance activities performed at the closed Pit 6 landfill during 2006, focusing on the fourth quarter (October to December). Results from quantitative analyses by state-certified analytical laboratories of chemical constituents of concern (COCs) in ground water samples are summarized in the report and listed in the appendices.

COC measurements made during the fourth quarter of 2006 do not differ significantly from past quarters. The data do not contain evidence of a new release of COCs from Pit 6 during 2006. A few COCs that were released to ground water from the landfill prior to its closure in 1998 continued to be detected including tritium, several volatile organic compounds (VOCs), and perchlorate. All required inspections and surveys of the Pit 6 cap were performed during 2006, demonstrating the continued functional and structural integrity of the cap, vegetative cover, and drainage structures.

## Introduction

Site 300 is the Lawrence Livermore National Laboratory (LLNL) Experimental Test Facility located in the Altamont Hills approximately 10.5 kilometers (km) (6.5 miles [mi]) southwest of downtown Tracy, California (**Figure 1**). Site 300 is owned by the United States Department of Energy (DOE) and is a 30.3 $km^2$ (11.8 $mi^2$) area site operated by the Regents of the University of California. The closed Pit 6 landfill is located within Site 300 near its southern boundary (**Figure 2**). A post-closure plan requiring quarterly and annual reports of compliance monitoring activities at the Pit 6 landfill (Ferry *et al*. 1998) was implemented during the second quarter of 1998.


**Figure 1. Location of LLNL Site 300.**

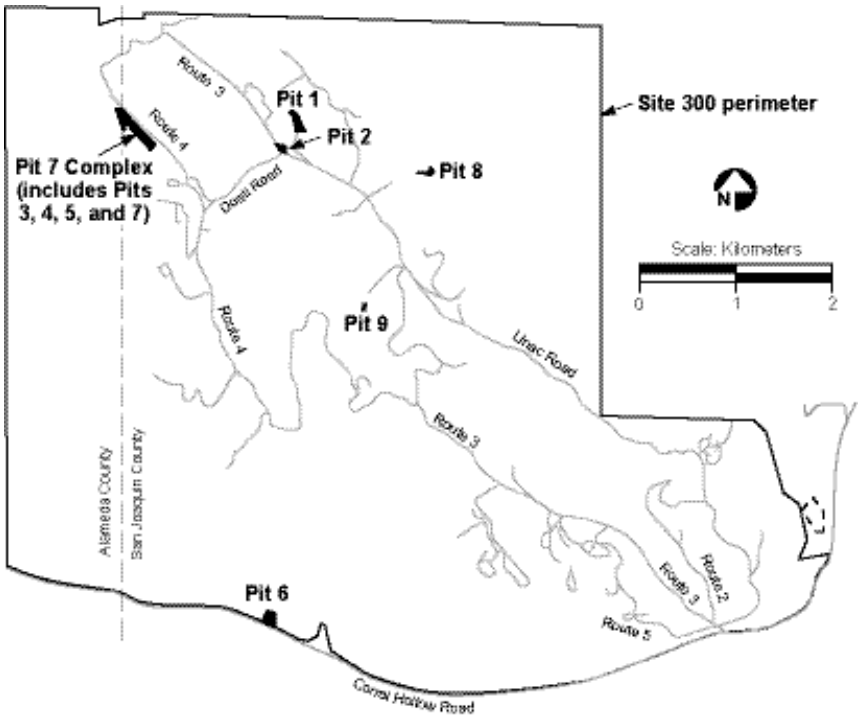



**Figure 2. Location of Pit 6 at LLNL Site 300.**

**Figure 3** shows the locations of the wells that are used to monitor the ground water in the vicinity of the Pit 6 landfill, including upgradient wells, detection monitoring wells, and corrective action monitoring wells (Ferry *et al.* 1998). The northern limit of the Carnegie-Corral Hollow Fault zone extends beneath Pit 6 as shown in **Figure 3**. Ground water flows southeastward, following the inclination (dip) of the underlying sedimentary rocks. Depths to the water table range from 10 to 20 meters (m) or 32.8 to 65.6 feet (ft) in terrace deposit gravels within the fault zone beneath Pit 6. Ground water flows within these gravels to the east-southeast parallel to the Site 300 boundary fence line (Webster-Scholten 1994).

## Monitoring Program Overview

The primary post-closure monitoring activity performed by LLNL at Pit 6 is the quarterly collection of ground water samples for chemical analyses. Field measurements of ground water physical parameters are collected at the time of sampling. Two ground water monitoring programs have been implemented at the Pit 6 landfill to ensure compliance with regulations. The Detection Monitoring Program (DMP) detects any new release of COCs to ground water from wastes buried in the Pit 6 landfill, while the Corrective Action Monitoring Program (CAMP) monitors the movement and fate of historically-released COCs in the ground water. COCs, as

defined by Title 23 of the *California Code of Regulations* (CCR), Chapter 15, are waste constituents, reaction products, and hazardous constituents that are reasonably expected to be in or derived from waste buried in the Pit 6 landfill.

Twenty-four COCs, including VOCs and radioisotopes, were identified initially for monitoring (Ferry *et al.* 1998). Perchlorate and nitrate were discovered subsequently in the ground water near Pit 6 during Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) site-wide surveys. Perchlorate was added to the COC list, and quarterly monitoring and reporting on it began during the third quarter of 2000. Since January 2003, an expanded set of CAMP wells (**Figure 3**) have been monitored for tritium activity, VOCs, nitrate, and perchlorate. Additional changes to the monitoring program implemented since January 2003 are discussed in **Appendix D**.

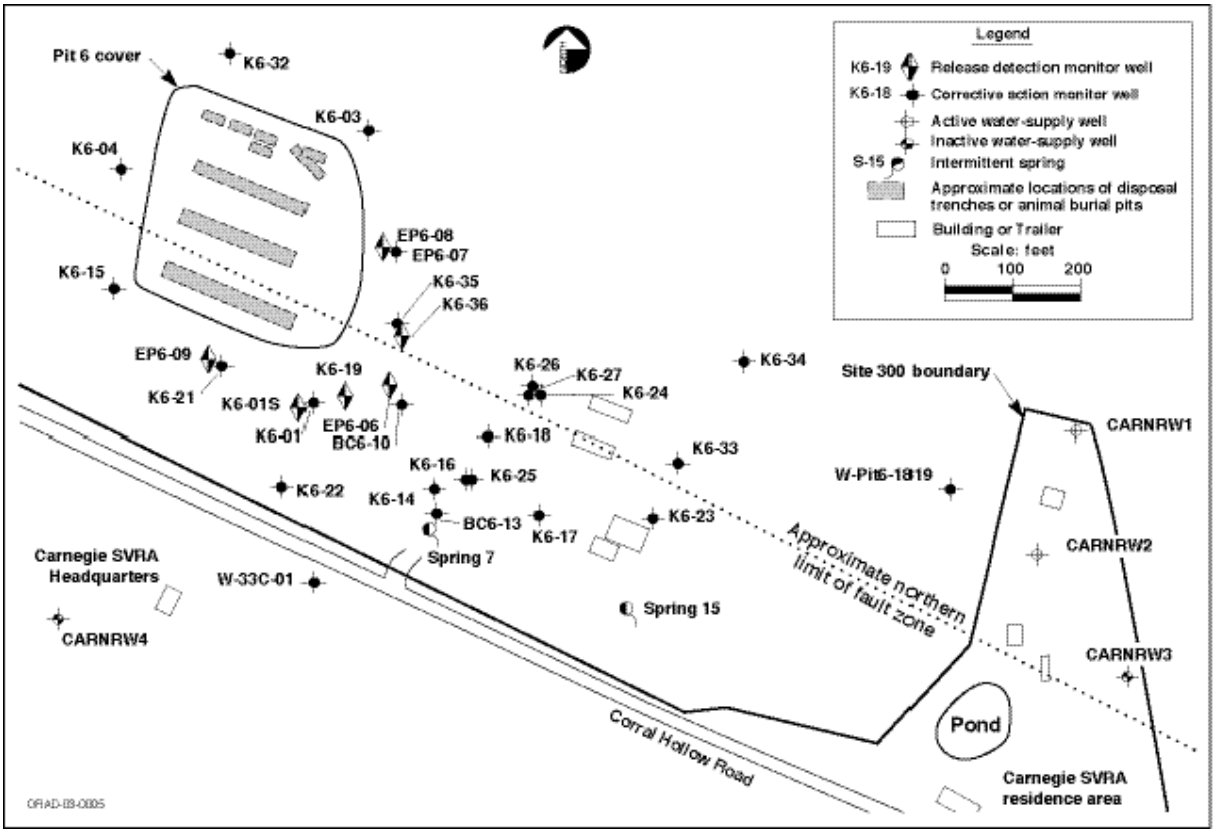



**Figure 3. Locations of Pit 6 monitoring wells.**

As required by DOE Order 241.1, our measurements are reported in *Système Internationale* (SI) units. The SI unit for radioactivity is the becquerel (Bq), equal to

1 nuclear disintegration per second. The more commonly used unit, picocurie (pCi), is equal to 1 nuclear disintegration per 27 seconds. As a convenience, maximum contaminant levels (MCLs) for radioactivity in drinking water are given in both becquerels per liter (Bq/L) and picocuries per liter (pCi/L) in **Table 1** below. Note that MCLs are provided for reference only, because this report does not involve wells used for potable domestic, livestock, or industrial water supply.

**Table 1. MCLs for radioactivity in drinking water.**

| Radiological parameter | **MCL** (Bq/L) | **MCL** (pCi/L) |
|---|---|---|
| Gross alpha | 0.555 | 15 |
| Gross beta | 1.85 | 50 |
| Tritium | 740 | 20,000 |
| Uranium (total) | 0.74 | 20 |

**DMP objective**. The primary DMP objective is to detect any new release of COCs to ground water. Ground water is sampled quarterly from six wells located hydraulically downgradient of Pit 6 along the point of compliance. These wells are identified as EP6-06, EP6-08, EP6-09, K6-01S (K6-01 if K6-01S is dry), K6-19, and K6-36 in **Figure 3**. Water samples are sent to state-certified laboratories where they are analyzed quantitatively for the presence (or absence) of COCs (see **Table C-1** for the list of DMP COCs). Gross alpha and gross beta radioactivity measurements are used as surrogates for seven radionuclide COCs other than uranium and tritium. Additional field measurements of ground water general parameters are obtained quarterly at the time of sample collection.

Potential releases of COCs from Pit 6 are indicated by comparing analytical results for ground water samples with statistically-determined limits of concentration, called statistical limits, or SLs (see **Appendix C**, **Table C-1**, for the list of COCs and their respective SLs). If a COC measurement exceeds an SL, the measurement is investigated further to determine its validity. Consistent with state regulations, two independent ground water samples, called retest samples, are obtained at least one week apart from the associated monitoring well and analyzed for the suspect COC. If the COC is present in either sample at a concentration that exceeds the SL, then the initial analysis is deemed to be validated and it is reported as statistically significant evidence of a release. If neither retest sample measurement exceeds the SL, then the initial exceedance is not confirmed, and a release report is not made. Any further

investigation of a COC is at the discretion of the Site 300 Remedial Project Managers (RPMs) and is conducted by LLNL under CERCLA.

**CAMP objectives**. The primary CAMP objectives are to: (1) evaluate the effectiveness of the corrective action, (2) evaluate natural attenuation of the ground water VOC and tritium plumes, (3) monitor perchlorate and nitrate in ground water, and (4) evaluate the need for implementing contingency actions. To accomplish the CAMP objectives, ground water measurements from the monitoring wells shown in **Figure 3** are evaluated on a quarterly basis as directed by the CAMP sampling plan.

Several VOCs, tritium, and perchlorate were released to ground water from Pit 6 prior to its closure. VOCs, primarily the solvents tetrachloroethene (PCE) and trichloroethene (TCE), have been described and evaluated previously in the *Final Site-Wide Remedial Investigation Report, Lawrence Livermore National Laboratory Site 300* (Webster-Scholten 1994), the *Final Feasibility Study for the Pit 6 Operable Unit, Lawrence Livermore National Laboratory Site 300* (Devany *et al*. 1994), the *Addendum to the Pit 6 Engineering Evaluation/Cost Analysis, Lawrence Livermore National Laboratory, Site 300* (Berry 1996), the *Final Site-Wide Feasibility Study for Lawrence Livermore National Laboratory Site 300* (Ferry *et al*. 1999), and the *Interim Site-Wide Record of Decision for Lawrence Livermore National Laboratory Site 300* (DOE 2001).

In previous Compliance Monitoring Program reports for the Pit 6 Landfill, ground water VOC concentration maps have been presented for TCE only. Starting in 2004, a new format for presenting CAMP VOC data was used to maintain consistency with the CERCLA Compliance Monitoring Report. In this report, the concentrations of all VOCs detected in ground water monitoring wells in the Pit 6 area have been summed and are presented as Total VOCs (TVOCs). The concentrations of individual compounds contributing to the TVOC concentration in each well are included in **Appendix B**, **Table B-2**.

Tritium activity is above the background in ground water downgradient from Pit 6, suggesting that a localized tritium release occurred prior to pit closure (Ferry *et al*. 1998). Monitored natural attenuation is the interim remedial action selected for the tritium plume.

Additional post-closure activities for Pit 6 include: (1) inspection of the landfill by LLNL technical staff annually and following major storms; (2) an annual comprehensive inspection of the landfill by an independent state-certified Professional Engineer (PE); (3) an annual pit cap elevation survey; (4) repairs as necessary to maintain the integrity of the landfill cap, its water diversion system, and its network of monitoring wells; and

(5) preparation of reports. Reports of post-closure activities are provided quarterly to the participating regulatory agencies for their information and use.

## Quality Assurance

To ensure data quality, LLNL works within the established Quality Assurance (QA) program of the LLNL Environmental Protection Department (EPD). LLNL uses protocols and procedures that cover all aspects of ground water sampling, sample tracking, and data management. These written protocols and procedures are contained in the *LLNL Livermore Site and Site 300 Environmental Restoration Project Standard Operating Procedures (SOPs)* (Dibley and Depue 2002), the *Environmental Monitoring Plan* (Woods, 2005), and the *EPD Quality Assurance Management Plan* (Clark 2006). Data quality is assessed by the following four methods: (1) analytical results for the routine and duplicate samples are compared by the analysts responsible for this report, (2) field blank samples are submitted to the analytical laboratories together with the routine ground water samples for identical analyses, (3) equipment blanks are prepared and analyzed to ensure that sampling equipment is properly cleaned before use, and (4) when samples are collected for VOC analysis, a trip blank (prepared at the analytical laboratory) is carried into the field. A summary of QA results may be found in **Appendix E, Table E-1**.

## DMP summary for fourth quarter 2006

COC measurements for the DMP wells are listed in **Appendix A**, **Table A-1**. Field measurements of ground water parameters and analytical laboratory measurements of total dissolved solids (TDS) for the DMP wells are listed in **Appendix A**, **Table A-2**. Data collected during the fourth quarter of 2006 do not differ significantly from past quarters (see Campbell and Taffet 2006a and Campbell and Taffet 2006b) and do not contain evidence of a new release of COCs from Pit 6.

The reporting limits provided by the analytical laboratory for Environmental Protection Agency (EPA) Methods 200.8:Be, 601, and 624 have been revised this quarter due to changes in the laboratory's data management systems. These revisions have affected the reported non-detect concentrations for the following COCs: beryllium, benzene, chloroform, 1,2-dichloroethane (cis-1,2-DCE), cis-1,2-dichloroethene, ethylbenzene, PCE, toluene, 1,1,1-trichloroethane, and total xylenes. In all these cases, the different reporting limits represent practical quantitation limits (PQLs) selected by the analytical laboratory, not a change in measured concentrations. LLNL has been working with the analytical laboratories to address this issue.

A few COCs that were released to ground water from the landfill prior to its closure in 1998 continue to be detected, including tritium and a few VOCs (**Table A-1**). Tritium activities continue to exceed the SL of 3.7 Bq/L (100 pCi/L) in ground water at downgradient DMP wells K6-19 (8.3 Bq/L [224 pCi/L]) and K6-01S (4.7 Bq/L [128 pCi/L]). Historical tritium activities for these two monitoring wells and well K6-36 are displayed in **Figure 4**. Tritium activities have remained well below the EPA drinking water MCL of 740 Bq/L (20,000 pCi/L) at these wells and activities appear to be relatively stable or decreasing.

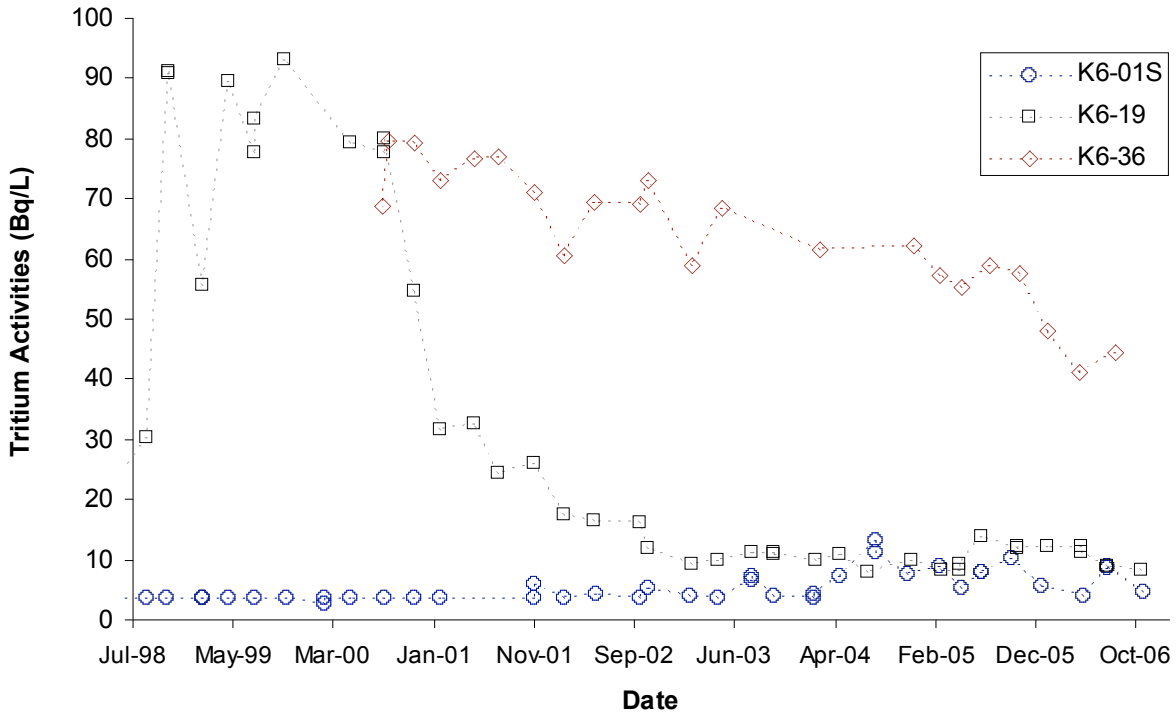



**Figure 4. Historical tritium activities at Pit 6 monitoring wells K6-01S, K6-19, and K6-36s.**

Total VOCs (TVOCs) results from Pit 6 monitoring wells are presented in the following CAMP summary. The VOC accounting for the largest proportion of the TVOCs is TCE. Therefore, the historical values for TCE concentrations measured in water samples collected from ground water monitoring wells EP6-09, K6-01S, and K6-19 are in **Figure 5**. The TCE concentrations also generally appear to be stable or decreasing. For a more detailed account and map of the Pit 6 tritium activities and TVOC concentrations, see the following CAMP summary.

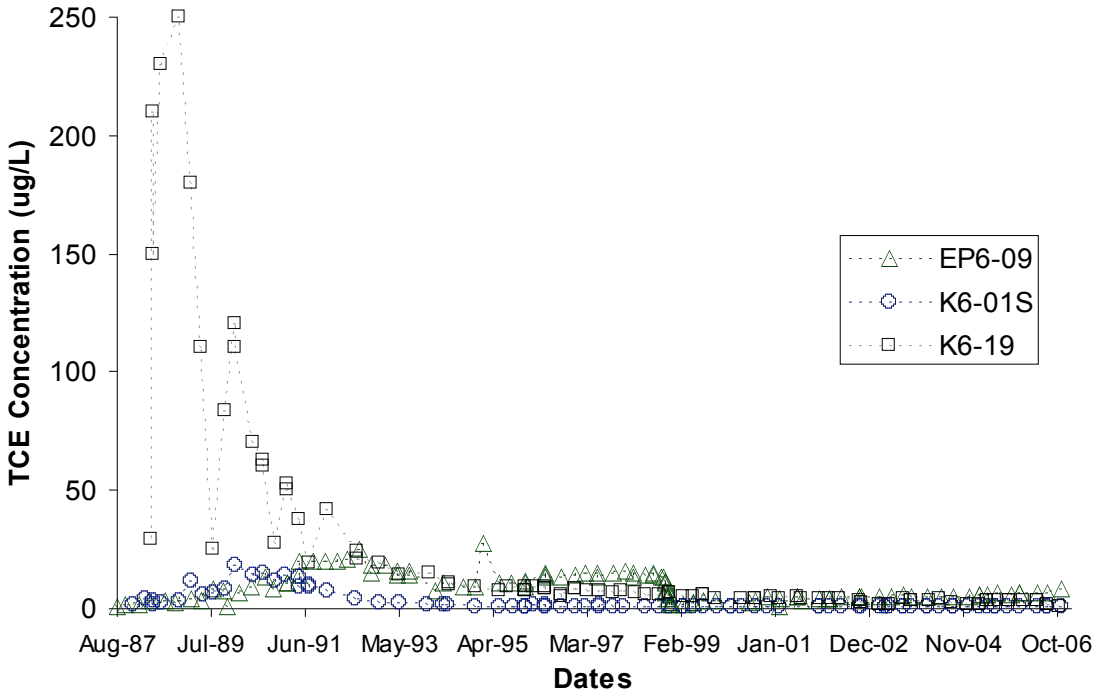



**Figure 5. Historical TCE concentrations at Pit 6 monitoring wells EP6-09, K6-01S, and K6-19.**

### CAMP summary for the fourth quarter 2006

This section summarizes an analysis of ground water elevation and COC data collected during the fourth quarter of 2006. The primary COCs for the Pit 6 area are several VOCs and tritium (Ferry *et al*. 1998). Perchlorate and nitrate were subsequently detected at concentrations above the PHG (State Public Health Goal) and MCL, respectively, in ground water samples from several Pit 6 monitoring wells during site-wide investigations by LLNL. Perchlorate was designated a secondary COC in 2000. Beginning in 2003, nitrate also became a secondary COC. Ground water elevations for the fourth quarter of 2006 are listed in **Table B-1**. Detections of VOCs, tritium, perchlorate, and nitrate in ground water samples collected during the fourth quarter are listed in **Tables B-2, B-3,** and **B-4**, respectively.

**Ground water elevations (GWE). Figure 6** is a ground water elevation contour map for the fourth quarter of 2006. Ground water elevations beneath Pit 6 are approximately a maximum of 10 m (30 ft) below the buried waste trenches. During the three-month period between the end of the third quarter of 2006 and end of the fourth quarter of 2006, ground water elevations north of the Corral Hollow-Carnegie Fault Zone generally were stable or increased slightly. Ground water elevations within the fault zone remained stable or declined by a maximum of 0.3 m (0.5 ft). The water

elevations measured during the fourth quarter 2006 at wells EP6-08 and K6-24 appear to be in error and were not used to contour the potentiometric surface.

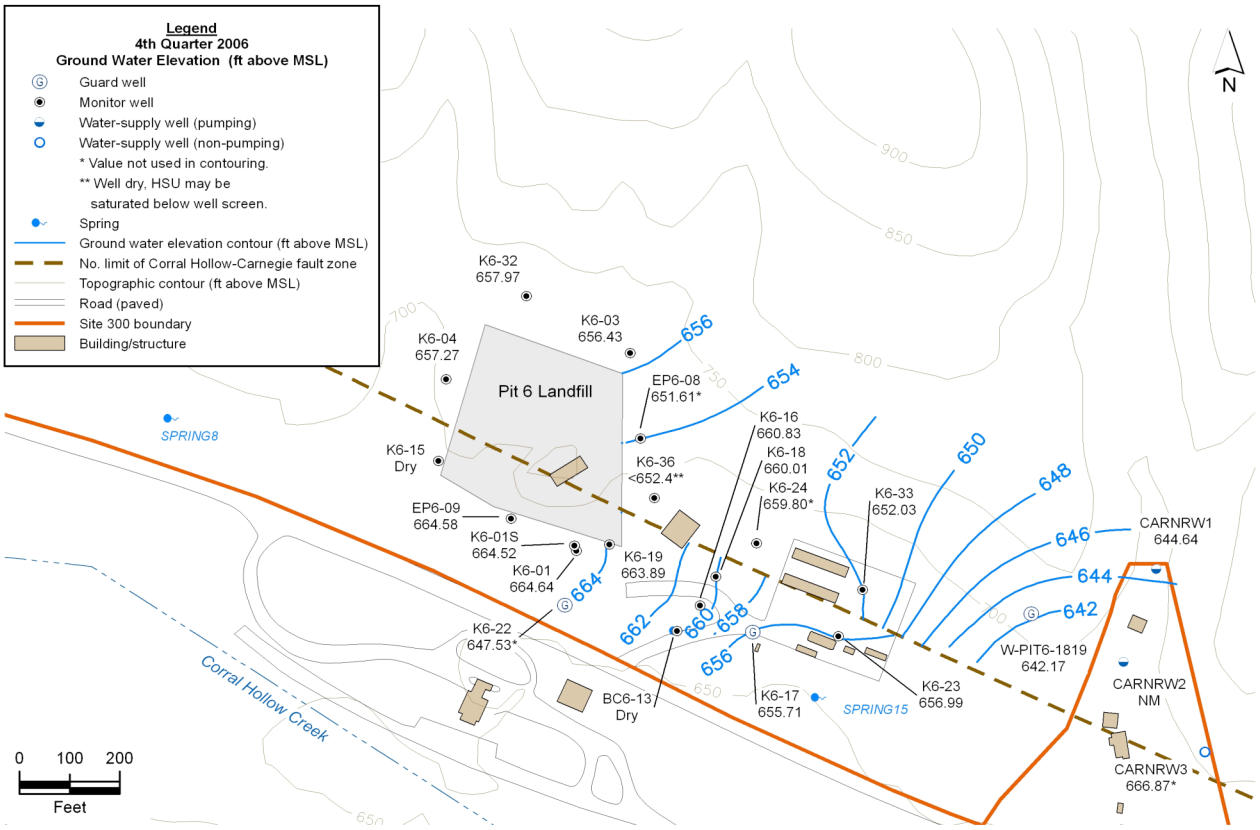
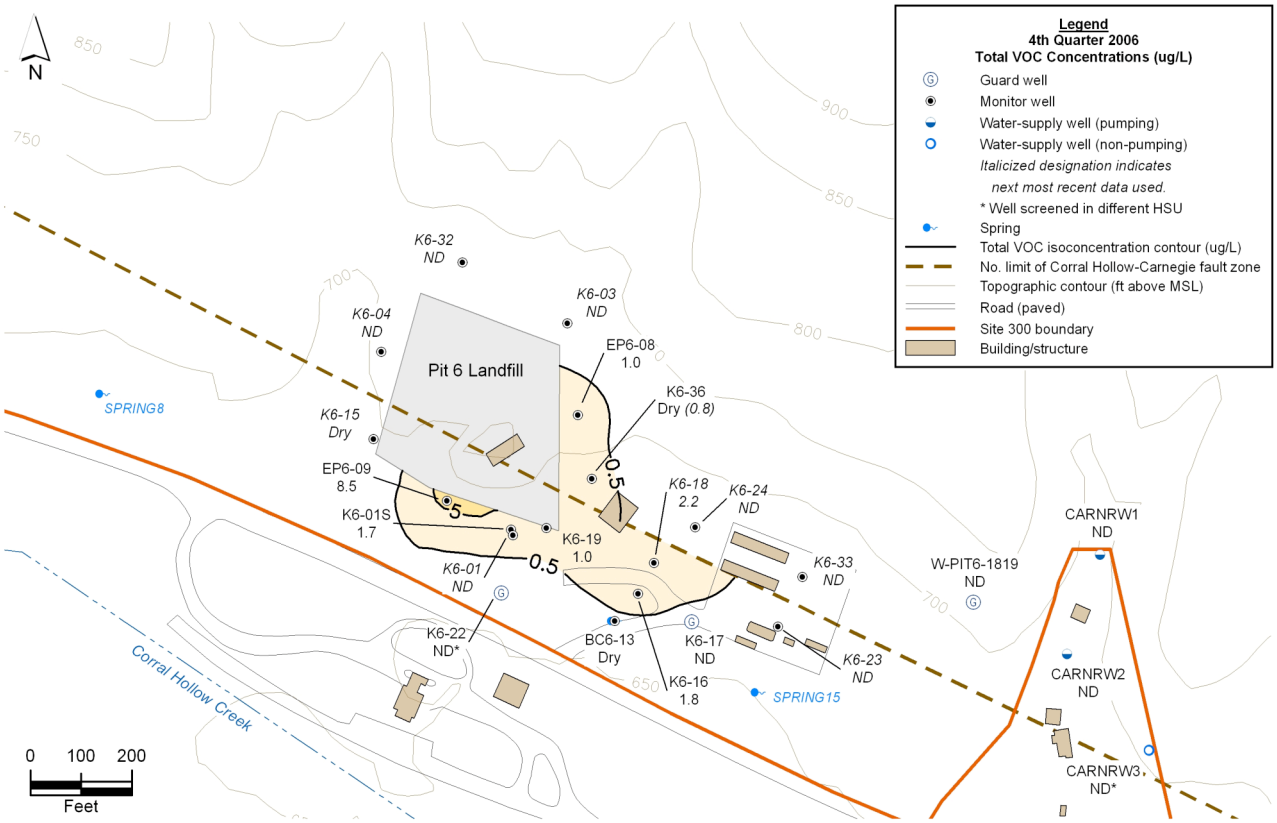



**Figure 6. Ground water elevations (ft above MSL) for the first water-bearing zone at Site 300 Pit 6, fourth quarter 2006.**

The predominantly southeast flow direction shown on **Figure 6** is consistent with potentiometric surface maps from previous quarters. Within the fault zone, ground water flows to the southeast with a hydraulic gradient of approximately 0.03. North of the fault zone, ground water flows to the southeast with a hydraulic gradient of approximately 0.01–0.02. Fractures in the Neroly formation $Tnbs_1$ stratigraphic unit play a dominant role in conveying ground water flow. A large component of the flow north of the fault is affected by pumping from offsite water-supply wells CARNRW1 and CARNRW2. As can be seen in the eastern portion of Figure 6, and especially in the vicinity of well W-PIT6-1819, ground water elevations north of the fault zone are strongly influenced by pumping from these wells. However, ground water elevations to the south, within the fault zone, do not appear to be strongly influenced by pumping.

**Ground water TVOC concentrations.** As shown in **Figure 7**, the concentrations of all the VOCs detected in ground water samples collected at Pit 6 during the fourth

quarter of 2006 have been summed and are presented as TVOCs. TCE, PCE, and cis-1, 2-DCE were the only VOCs detected at Pit 6 in ground water at concentrations above the method reporting limit of 0.5 µg/L (for each compound) during the fourth quarter 2006.




**Note**: If fourth quarter data was not collected for a well, data from the most recent sample collected during 2006 is displayed or used for contouring

**Figure 7. Ground water TVOC concentrations (µg/L) in the first water-bearing zone at Site 300 Pit 6, fourth quarter** (*or most recent*) **2006.**

**Figure 7** shows the distribution of TVOC concentrations in the shallow water-bearing zone (WBZ) for the fourth quarter of 2006. The distribution is similar to last quarter's. Within the fault zone, TVOCs were detected last quarter in ground water samples from monitoring wells EP6-09, K6-01S, K6-16, K6-18, and K6-19. This quarter, wells EP6-08, EP6-09, K6-01S, and K6-19 yielded samples that contained VOCs. The other wells that yielded VOCs last quarter (wells K6-16 and K6-18) are only sampled twice a year (during the first and third quarters) per CERCLA Comprehensive Monitoring Plan (CMP) requirements. These wells define a localized VOC plume that originates in the east-central portion of Pit 6. The concentrations of individual VOCs in

ground water samples collected during the fourth quarter of 2006 are listed in **Table B-2**.

Ground water TCE concentrations during the fourth quarter of 2006 were similar to those detected in previous quarters and years. The maximum ground water TCE concentration at Pit 6 this quarter was 8.5 μg/L in a ground water sample collected from well EP6-09. Ground water samples collected from this well during the previous two quarters contained 6.6 μg/L of TCE. The maximum historical TCE concentration for this well was 28 μg/L, occurring on January 27, 1995. By year, the maximum TCE concentrations measured in ground water were 6.3 μg/L in 2000 (well K6-18), 5.4 μg/L in 2001 (well K6-19), 5.1 μg/L in 2002 (well EP6-09), 5.5 μg/L in 2003 (well EP6-09), 5.4 μg/L in 2004 (well EP6-09), 6.4 μg/L in 2005 (well EP6-09), and 8.5 μg/L this year (well EP6-09). The monitoring data do not indicate a new release of TCE to ground water from Pit 6 during this quarter.

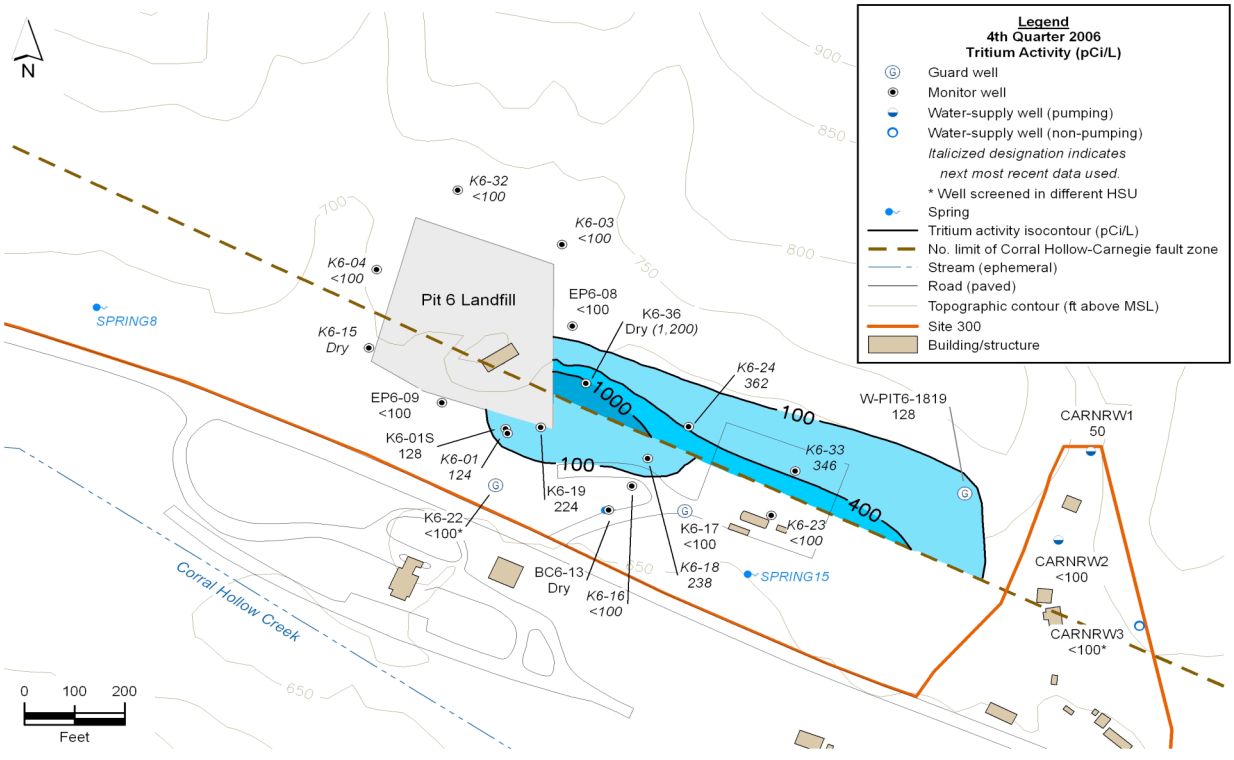
As in the past, cis-1,2-DCE was detected in ground water samples from Pit 6. During the fourth quarter of 2006, 1.7 μg/L of cis-1,2-DCE were detected in the ground water sample from well K6-01S. Last quarter, cis-1,2-DCE was detected in one ground water sample, from well K6-01S, at a concentration of 2.3 μg/L. The previous detections of cis-1,2-DCE (third and fourth quarters of 2005 and first and second quarters of 2006) in samples from this well were 2.4, 2.0, 2.5, and 2.4 μg/L, respectively. The presence of cis-1,2-DCE, a degradation product of TCE, suggests that natural decomposition may be occurring.

This quarter, PCE was detected in a ground water sample from one well, EP6-08, at a concentration of 1 μg/L. Until this quarter, PCE had not been detected in Pit 6 ground water since the third quarter of 2005. During the third quarter of 2005, 0.77 μg/L of PCE were detected in the ground water sample from well EP6-08. The previous detection (second quarter 2005) for this well was 0.97 μg/L. PCE was also detected in the third quarter 2005 ground water sample from well K6-36 at a concentration of 0.6 μg/L. Other recent detections of PCE in ground water from well K6-36 were 0.64 μg/L during the second quarter of 2005 and 0.68 μg/L during the first quarter of 2005. Monitoring of PCE in ground water samples from well EP6-08 will continue to identify any short term concentration trends.

**Ground water tritium activity**. **Figure 8** shows the areal distribution of tritium activities in ground water for the fourth quarter of 2006. During the fourth quarter 2006, tritium activities in excess of the 3.7 Bq/L (100 pCi/L) detection limit were found in ground water samples from well W-PIT6-1819 north of the fault zone, and from wells K6-01S, and K6-19 within the fault zone. Well K6-36 was dry during the quarter, but we assumed that the water-bearing zone was saturated below the well screen and last

quarter's tritium activity of 1,200 pCi/L was used in the contouring so that a 1,000 pCi/L contour is present north of the fault zone. Last quarter, wells K6-01, K6-01S, K6-18, K6-19, K6-24, K6-33, and K6-36 yielded ground water samples containing tritium in excess of the 3.7 Bq/L (100 pCi/L) detection limit. During the second quarter 2006, tritium activities in excess of the detection limit were found in ground water samples from well K6-36 north of the fault zone, and from wells K6-01S, and K6-19 within the fault zone. Wells K6-01S, K6-18, K6-24, and K6-33 were not sampled during the second or fourth quarters because samples for tritium analysis are only required during the first and third quarters.

This quarter, because well K6-36 was dry, the highest measured ground water tritium activity was 8.3 Bq/L (224 pCi/L) in the sample from well K6-19. Last quarter, the highest tritium activity was measured in the ground water sample from well K6-36, north of the fault zone, at an activity of 44.4 Bq/L (1,200 pCi/L). During the second quarter, this well yielded a ground water sample that contained 41.1 Bq/L (1,100 pCi/L). During 2005, tritium activity in well K6-36 ground water was a maximum of 58.9 Bq/L (1,590 pCi/L) in a sample collected during the third quarter of 2005. Tritium activities in samples from this well (K6-36) have decreased from an historical maximum of 126.5 Bq/L (3,420 pCi/L) in 2003.

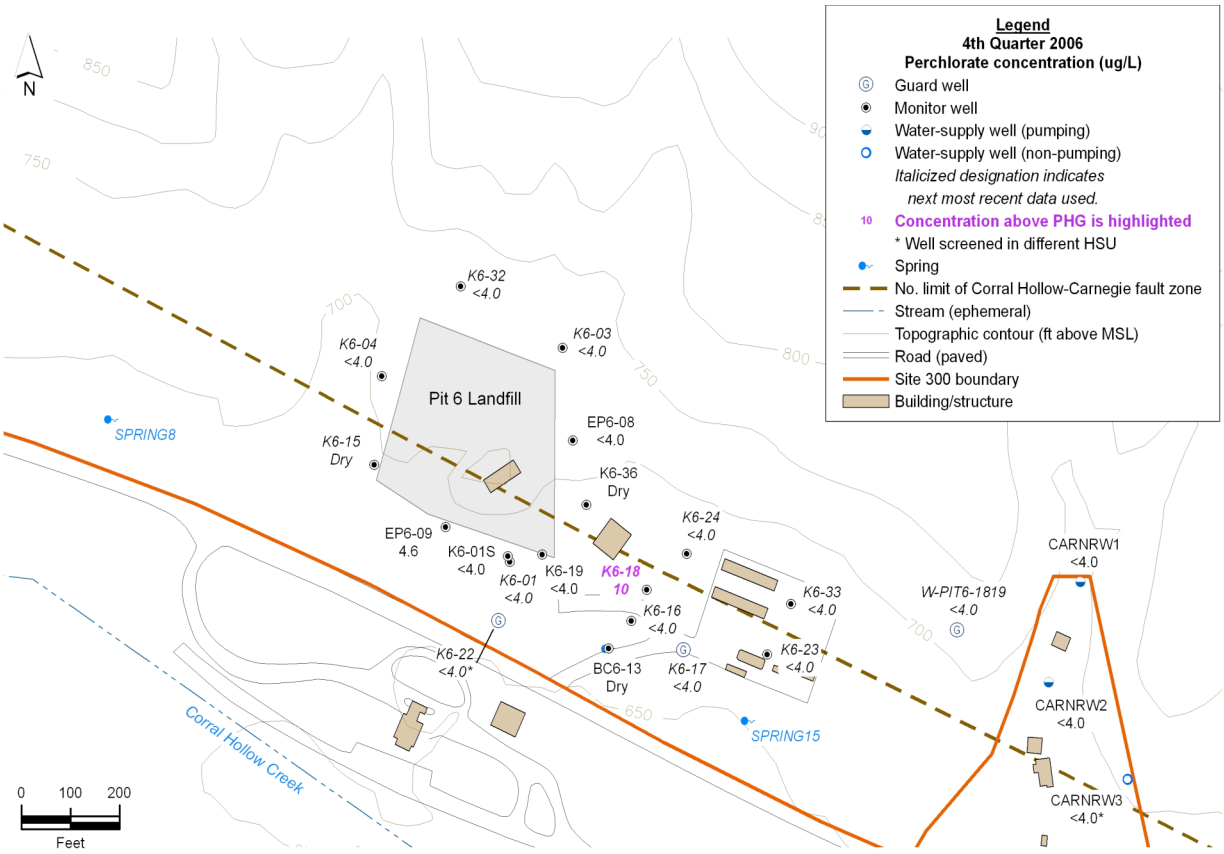



**Note**: If fourth quarter data was not collected for a well, data from the most recent sample collected during 2006 is displayed or used for contouring

**Figure 8 Ground water tritium activities (pCi/L) in the first water-bearing zone at Site 300 Pit 6, fourth quarter** (*or most recent*) **2006.**

Well W-Pit6-1819 is a guard well and is used to define the downgradient extent of the tritium plume. It is located about 30 m (100 ft) west of the Site 300 boundary with the Carnegie State Vehicle Recreation Area residence area and about 60 m (200 ft) west of the CARNRW1 and CARNRW2 water-supply wells (**Figure 8**). During the fourth quarter 2006, this well yielded a ground water sample containing a tritium activity slightly above the 3.7 Bq/L (100 pCi/L) detection limit. During the second and third quarters of 2006, the ground water at well W-Pit6-1819 has contained tritium below the detection limit. During the first quarter of 2006, the ground water sample from this well contained 5.1 Bq/L (137 pCi/L) of tritium. The ground water from well W-Pit6-1819 contained a tritium activity of 5.1 Bq/L (137 pCi/L) during the first quarter 2005, <3.7 Bq/L (<100 pCi/L) during the second quarter 2005, 6.1 Bq/L (164 pCi/L) during the third quarter of 2005, and 5.8 Bq/L (156 pCi/L) during the fourth quarter of 2005. Tritium activities were below the detection level of 3.7 Bq/L (100 pCi/L) in the monthly ground water samples obtained during the second quarter of 2006 from the off-site CARNRW wells. Based on these analyses, the tritium plume appears to be relatively stable and tritium activities in ground water samples from monitoring wells within the plume are generally decreasing.

**Ground water perchlorate concentrations**. A map showing fourth quarter 2006 perchlorate concentrations in ground water samples collected from the shallow water-bearing zone is presented in **Figure 9**. This quarter, one well, EP6-09, yielded a ground water sample that contained perchlorate in excess of the reporting limit of 4 μg/L (4.6 μg/L). During the previous two quarters, none of the wells yielded ground water samples containing perchlorate concentrations at or above the reporting limit of 4 μg/L. During the first quarter of 2006, two wells yielded ground water samples containing perchlorate. Wells EP6-09 and K6-18 yielded samples containing 6.7 and 10 μg/L of perchlorate, respectively. Of these two wells, only well EP6-09 was sampled this quarter. A sample was not required this quarter from well K6-18. The State Public Health Goal (PHG) for perchlorate is 6 μg/L. In the past, the maximum perchlorate concentrations in ground water at Pit 6 have been measured at well K6-18 (15 μg/L in 2002, 14 μg/L in 2003, and 14 μg/L in 2004). Perchlorate was not detected in ground water samples collected from the Pit 6 area during 2005. The available data indicate a generally decreasing trend in perchlorate concentrations in Pit 6 area ground water.

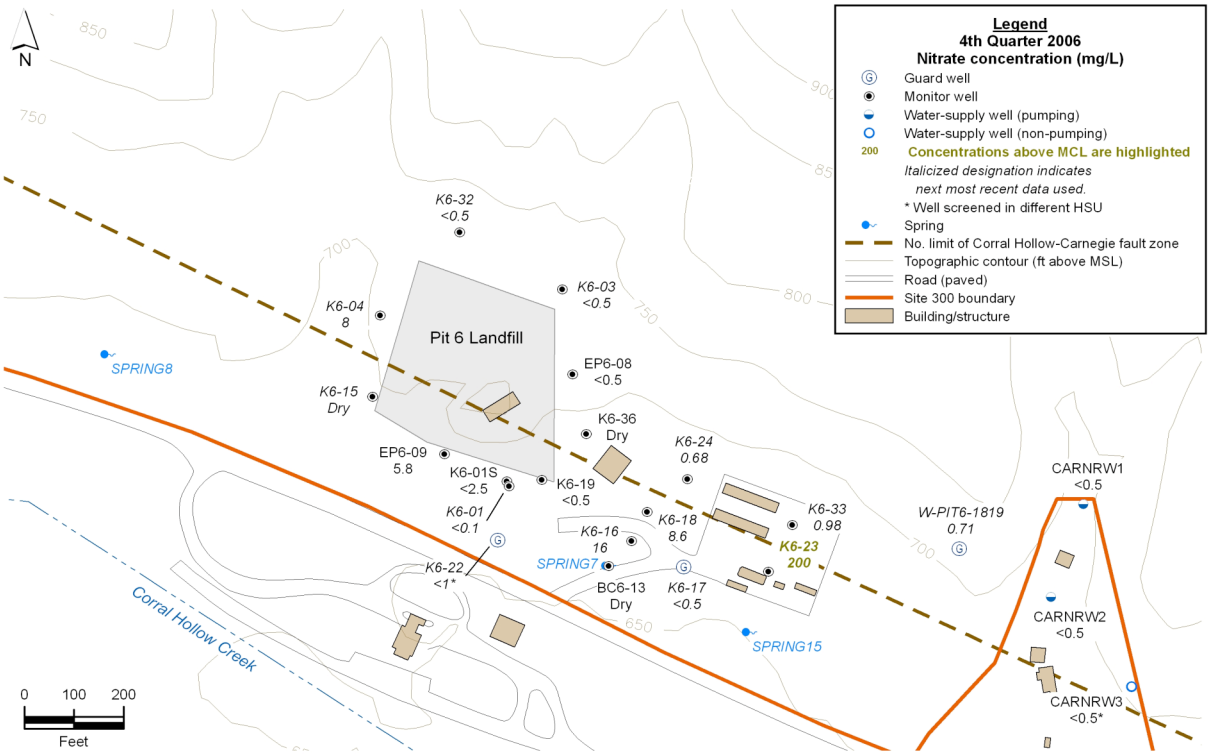



**Note**: If fourth quarter data was not collected for a well, data from the most recent sample collected during 2006 is displayed or used for contouring

**Figure 9. Ground water perchlorate concentrations (µg/L) in the first water-bearing zone at Site 300 Pit 6, fourth quarter** (*or most recent*) **2006.**

**Ground water nitrate concentrations.** A map showing fourth quarter 2006 nitrate concentrations in the shallow water-bearing zone at Pit 6 is presented in **Figure 10**. During the fourth quarter of 2006, nitrate was detected in samples from 2 of 9 wells sampled at Pit 6. The ground water sampled from wells EP6-09 and CARNRW3 contained 5.8 and 0.37 mg/L of nitrate, respectively. During the third quarter of 2006, nitrate was detected in ground water samples from 4 of 14 wells sampled in the study area at concentrations ranging from 0.3 to 3.9 mg/L. One monitoring well at Pit 6, K6-23, consistently yields ground water nitrate concentrations in excess of the MCL. During the first quarter of 2006, the sample from well K6-23 yielded 200 mg/L of nitrate. The well was not sampled for nitrate during the second, third, or fourth quarters of 2006. Ground water nitrate concentrations from this well are consistently the highest at Pit 6 and were 172, 165, and 200 mg/L in 2003, 2004, and 2005, respectively. Well K6-23 is located in close proximity to the Building 899 septic system, which may be a potential source of the nitrate at this location. Two of the third quarter

2006 ground water samples from the CARNRW wells (CARNRW2 and CARNRW3) contained < 0.5 mg/L of nitrate and two (from CARNRW1 and CARNRW4) contained maximum nitrate concentrations of 0.59 and 2.5 mg/L, respectively.




**Note**: If fourth quarter data was not collected for a well, data from the most recent sample collected during 2006 is displayed or used for contouring

**Figure 10. Ground water nitrate concentrations (mg/L) in the first water-bearing zone at Site 300 Pit 6, fourth quarter** (*or most recent*) **2006.**

## Inspection and Maintenance summary

Inspections of the Pit 6 cap were performed by LLNL staff for the fourth quarter on November 28, 2006. These, like all quarterly visual cap inspections in 2006, include a check list of issues related to cap integrity, vegetation, and drainage. No deficiencies were noted in the condition of the pit cap in the fourth quarter or in any other quarter during 2006. During the second quarter 2006 the required annual inspection was performed by a Principle Engineer (PE) from Abri Environmental Engineering. As reported in the second quarter report the pit cap and drainage structures were observed to be in good functioning condition. A few recommendations were made regarding vegetative cover, maintaining the drainage ditches, and filling large animal burrows. These recommendations have been addressed by LLNL. The survey of the fixed elevation markers on the pit cap occurred during the third quarter 2006 and found no major issues. The combined evidence of the quarterly visual inspections, annual PE inspection, and annual fixed elevation marker survey reveal that the Pit 6 cap has been in good, functioning condition during 2006.

## References

Berry, T. (1996), *Addendum to the Pit 6 Engineering Evaluation/Cost Analysis, Lawrence Livermore National Laboratory, Site 300*, Lawrence Livermore National Laboratory, Livermore, CA (UCRL-AR-113861 Add.).

*California Code of Regulations* (CCR), Title 23, Division 3, Chapter 15, Section 2550.7.

Campbell, C.G. and M.J. Taffet (2006a), *LLNL Experimental Test Site 300 Compliance Monitoring Program for the CERCLA-Closed Pit 6 Landfill First Quarter Report January – March 2006,* Lawrence Livermore National Laboratory, Livermore, CA (UCRL-AR-10191-06-1).

Campbell, C.G. and M.J. Taffet (2006b), *LLNL Experimental Test Site 300 Compliance Monitoring Program for the CERCLA-Closed Pit 6 Landfill Second Quarter Report April – June 2006,* Lawrence Livermore National Laboratory, Livermore, CA (UCRL-AR-10191-06-2).

Clark, C. (2001), *Environmental Protection Department Quality Assurance Management Plan-2006*, Lawrence Livermore National Laboratory, Livermore, CA (UCRL-AR-146357 Rev. 6), September 2006.

Devany, R., *et al.* (1994), *Final Feasibility Study for the Pit 6 Operable Unit, Lawrence Livermore National Laboratory Site 300*, Lawrence Livermore National Laboratory, Livermore, CA (UCRL-AR-113861).

Dibley, V., and R. Depue (2002), *LLNL Livermore Site and Site 300 Environmental Restoration Project Standard Operating Procedures (SOPs),* Lawrence Livermore National Laboratory, Livermore, CA (UCRL-MA-109115 Rev. 9), February 2002.

Ferry, L., T. Berry, and D. MacQueen (1998), *Post-Closure Plan for the Pit 6 Landfill Operable Unit, Lawrence Livermore National Laboratory Site 300*, Lawrence Livermore National Laboratory, Livermore, CA (UCRL-AR-128638).

Ferry, L., R. Ferry, W. Isherwood, R. Woodward, T. Carlsen, Z. Dimer, R. Qadir, and M. Dresen (1999), *Final Site-Wide Feasibility Study for Lawrence Livermore National Laboratory Site 300*, Lawrence Livermore National Laboratory, Livermore, CA (UCRL-AR-132609).

Ferry, L., R. Ferry, M. Dresden, and T. Carlsen (2002), *Compliance Monitoring Plan/Contingency Plan for Interim Remedies at Lawrence Livermore National Laboratory Site 300,* Lawrence Livermore National Laboratory, Livermore, CA (UCRL-AR-147570).

Galles, H. L., to S. Timm (1998), Letter: *Statistically Significant Evidence for a Release of 1,2-Dichloroethane from Pit 6* (WGMG98:282, October 13, 1998).

Raber, E., to T. Park, K. Setian, and S. Timm (2002), Letter: *Statistically Significant Evidence for a Release of Perchlorate from Lawrence Livermore National Laboratory Experimental Test Site (Site 300) Pit 6* (WGMG02:182, November 8, 2002).

Raber, E., to T. Park, K. Setian, and S. Timm (2004), Letter: *Statistically Significant Evidence for a Release of Perchlorate from Lawrence Livermore National Laboratory Experimental Test Site (Site 300) Pit 6* (WGMG04:055, May 10, 2004).

U.S. Department of Energy (DOE) (2001), *Interim Site-Wide Record of Decision for Lawrence Livermore National Laboratory Site 300*, Lawrence Livermore National Laboratory, Livermore, CA (UCRL-AR-138470).

Webster-Scholten, C. P. (Ed.) (1994), *Final Site-Wide Remedial Investigation Report, Lawrence Livermore National Laboratory Site 300,* Lawrence Livermore National Laboratory, Livermore, CA (UCRL-AR-108131).

Woods, N. (Ed.) (2005), *Environmental Monitoring Plan,* Lawrence Livermore National Laboratory, Livermore, CA (UCRL-ID-106132 Rev. 4).

**Acknowledgments**

The compliance monitoring program for Pit 6 could not be conducted without the dedicated efforts of many people. Eric Walter coordinated the sampling activities. Mark Campbell sampled the monitoring wells and packaged the samples for shipment to the off-site analytical laboratories. Off-site analytical support was provided by BC Laboratories, Inc., Caltest Analytical Laboratory, and Eberline Services. Mike Taffet, Suzie Chamberlain, Becky Goodrich and Della Burruss performed quality reviews and data table preparation. Monique de Vasconcelos provided essential administrative assistance. We thank James Lane, Karen Folks, Dawn Chase and Joe Perez at Site 300 for their cooperation in this effort. A draft of this report was reviewed by LLNL peers, whose suggestions for improvements are incorporated.

## Abbreviations and Acronyms

| | |
|---|---|
| Bq | becquerel (international unit of radioactivity equal to 27 pCi) |
| CAMP | Corrective Action Monitoring Program |
| CC | control chart (statistical method) |
| CCR | California Code of Regulations |
| CERCLA | Comprehensive Environmental Response, Compensation, and Liability Act |
| Cis-1,2-DCE | Cis-1,2-dichloroethene |
| CL | concentration limit (background concentration of a chemical) |
| COC | constituent of concern |
| CVRWQCB | Central Valley Regional Water Quality Control Board |
| DEHP | di(2-ethylhexyl)phthalate, bis(2-ethylhexyl)phthalate |
| DMP | Detection Monitoring Program |
| DOE | U.S. Department of Energy |
| DTSC | California Department of Toxic Substances Control |
| EPA | U.S. Environmental Protection Agency |
| EPD | LLNL Environmental Protection Department |
| ERD | LLNL Environmental Restoration Division |
| ft | foot (used as a measure of elevation above MSL) |
| GWD | ground water depth |
| GWE | ground water elevation in feet above MSL |
| km | kilometer |
| L | liter |
| LLNL | Lawrence Livermore National Laboratory |
| m | meter |
| MCL | maximum contaminant level (for drinking water) |
| MSL | mean sea level (datum for elevation measurements) |
| mg | milligram |
| $\mu$g | microgram |
| nd | none detected |
| PCB | polychlorinated biphenyl |
| PCE | perchloroethene, tetrachloroethene |
| pCi | picocurie (unit of radioactivity) |
| PE | Professional Engineer |
| PI | prediction interval (statistical method) |
| PQL | practical quantitation unit |
| QA | quality assurance |

| | |
|---|---|
| RL | reporting limit (contractual concentration near zero) |
| RPM | remedial project manager |
| Site 300 | Experimental Test Facility, LLNL |
| SL | statistically determined concentration limit |
| SOP | standard operating procedure |
| TCE | trichloroethene |
| TDS | total dissolved solids |
| THM | trihalomethane |
| $Tnbs_1$ | Neroly Formation lower blue sandstone unit |
| TVOC | total volatile organic compound |
| VOC | volatile organic compound |
| WBZ | water bearing zone |
| yr | year |

# Appendix A

# Tables of Ground Water Measurements

# for Detection Monitoring Wells

**Table A-1. Pit 6 post-closure monitoring plan constituents of concern (COCs) detection monitoring wells, SLs, MCLs, and quarterly analytical results for 2006.**

| | | | | Quarter | | | |
|---|---|---|---|---|---|---|---|
| **COC (units)** | **Well** | **SL** | **MCL** | **First** | **Second** | **Third** | **Fourth** |
| **Metals (μg/L)** | | | | | | | |
| Beryllium | EP6-06 | 0.2 | 4 | < 0.5 [(b)] | < 0.5 | < 0.5 | < 0.5 |
| | EP6-08 | 0.2 | | < 0.5 | < 0.5 | < 0.5 | < 0.5 |
| | EP6-09 | 0.2 | | < 0.5 | < 0.5 | < 0.5 | < 0.5 |
| | K6-01S | 0.2 | | < 0.5 | < 0.5 | < 0.5 | < 0.5 |
| | K6-19 | 0.2 | | < 0.5 | < 0.5 | < 0.5 | < 0.5 |
| | K6-36 | 0.2 | | < 0.5 | < 0.5 | < 0.5 | DRY |
| Mercury | EP6-06 | 0.2 | 2 | < 0.2 | < 0.2 | < 0.2 | < 0.2 |
| | EP6-08 | 0.2 | | < 0.2 | < 0.2 | < 0.2 | < 0.2 |
| | EP6-09 | 0.2 | | < 0.2 | < 0.2 | < 0.2 | < 0.2 |
| | K6-01S | 0.2 | | < 0.2 | < 0.2 | < 0.2 | < 0.2 |
| | K6-19 | 0.2 | | < 0.2 | < 0.2 | < 0.2 | < 0.2 |
| | K6-36 | 0.2 | | < 0.2 | < 0.2 | < 0.2 | DRY |
| **Radioactivity (Bq/L)** | | | | | | | |
| Tritium | EP6-06 | 3.7 | 740 | -1.0 | -1.9 | -1.3 | -3.0 |
| | EP6-08 | 3.7 | | -2.1 | -0.1 | -2.6 | -1.3 |
| | EP6-09 | 3.7 | | 29.4 | 1.4 | 2.4 | 3.0 |
| | K6-01S | 3.7 | | 5.6 | 3.8 | 8.7 | 4.7 |
| | K6-19 | 3.7 | | 12.3 | 12.2 | 9.0 | 8.3 |
| | K6-36 | 88 | | 48.1 | 41.1 | 44.4 | DRY |
| Uranium (total) | EP6-06 | 0.13 | 0.74 | 0.016 | 0.009 | 0.021 | 0.024 |
| | EP6-08 | 0.06 | | 0.026 | 0.020 | 0.031 | 0.006 |
| | EP6-09 | 0.14 | | 0.080 | 0.085 | 0.089 | 0.077 |
| | K6-01S | 1.00 | | 0.158 | 0.152 | 0.144 | 0.165 |
| | K6-19 | 0.27 | | 0.107 | 0.097 | 0.104 | 0.104 |
| | K6-36 | 0.05 | | 0.029 | 0.015 | 0.016 | DRY |
| Gross alpha | EP6-06 | 0.29 | 0.56 | -0.043 | 0.046 | -0.043 | -0.010 |
| | EP6-08 | 0.15 | | 0.018 | -0.035 | 0.030 | -0.035 |
| | EP6-09 | 0.18 | | 0.018 | -0.033 | -0.065 | -0.262 |
| | K6-01S | 0.95 | | 0.077 | -0.162 | -1.032 | -0.258 |
| | K6-19 | 0.34 | | 0.056 | 0.094 | 0.072 | -0.053 |
| | K6-36 | 0.07 | | -0.034 | -0.004 | -0.020 | DRY |
| Gross beta | EP6-06 | 0.79 | 1.85 | 0.242 | 0.250 | 0.295 | 0.315 |
| | EP6-08 | 0.79 | | 0.309 | 0.381 | 0.344 | 0.699 |
| | EP6-09 | 0.79 | | 0.451 | 0.403 | 0.389 | 0.377 |
| | K6-01S | 2.13 | | 0.792 | 0.681 | 0.644 | 0.755 |
| | K6-19 | 0.79 | | 0.309 | 0.339 | 0.309 | 0.237 |
| | K6-36 | 0.97 | | 0.269 | 0.295 | 0.267 | DRY |
| **Volatile organic compounds (μg/L, EPA method 601 or 624)** | | | | | | | |
| Benzene | EP6-06 | 0.5 | 1 | < 1[(b)] | < 1 | < 1 | < 1 |
| | EP6-08 | 0.5 | | < 1 | < 1 | < 1 | < 1 |
| | EP6-09 | 0.5 | | < 1 | < 1 | < 1 | < 1 |
| | K6-01S | 0.5 | | < 1 | < 1 | < 1 | < 1 |
| | K6-19 | 0.5 | | < 1 | < 1 | < 1 | < 1 |
| | K6-36 | 0.5 | | < 1 | < 1 | < 1 | DRY |

**Table A-1. Pit 6 post-closure monitoring plan constituents of concern (COCs) detection monitoring wells, SLs, MCLs, and quarterly analytical results for 2006.**

| | | | | Quarter | | | |
|---|---|---|---|---|---|---|---|
| **COC (units)** | **Well** | **SL** | **MCL** | **First** | **Second** | **Third** | **Fourth** |
| Carbon disulfide | EP6-06 | 5 | none | < 1 | < 1 | < 1 | < 1 |
| | EP6-08 | 5 | | < 1 | < 1 | < 1 | < 1 |
| | EP6-09 | 5 | | < 1 | < 1 | < 1 | < 1 |
| | K6-01S | 5 | | < 1 | < 1 | < 1 | < 1 |
| | K6-19 | 5 | | < 1 | < 1 | < 1 | < 1 |
| | K6-36 | 5 | | < 1 | < 1 | < 1 | DRY |
| Chloroform | EP6-06 | 0.5 | 80 | < 1[(b)] | < 1 | < 1 | < 1 |
| | EP6-08 | 1.0 | | < 1 | < 1 | < 1 | < 1 |
| | EP6-09 | 0.5 | | < 1 | < 1 | < 1 | < 1 |
| | K6-01S | 0.5 | | < 1 | < 1 | < 1 | < 1 |
| | K6-19 | 1.5 | | < 1 | < 1 | < 1 | < 1 |
| | K6-36 | 0.5 | | < 1 | < 1 | < 1 | DRY |
| 1,2-dichloroethane | EP6-06 | 0.5 | 0.5 | < 1[(b)] | < 1 | < 1 | < 1 |
| | EP6-08 | 0.5 | | < 1 | < 1 | < 1 | < 1 |
| | EP6-09 | 0.5 | | < 1 | < 1 | < 1 | < 1 |
| | K6-01S | 0.5 | | < 1 | < 1 | < 1 | < 1 |
| | K6-19 | 0.5 | | < 1 | < 1 | < 1 | < 1 |
| | K6-36 | 0.5 | | < 1 | < 1 | < 1 | DRY |
| Cis-1,2-dichloroethene | EP6-06 | 0.5 | 6 | < 1[(b)] | < 1 | < 1 | < 1 |
| | EP6-08 | 0.5 | | < 1 | < 1 | < 1 | < 1 |
| | EP6-09 | 0.5 | | < 1 | < 1 | < 1 | < 1 |
| | K6-01S | 7.0 | | 2.5 | 2.4 | 2.2 | 1.7 |
| | K6-19 | 0.5 | | < 1 | < 1 | < 1 | < 1 |
| | K6-36 | 0.5 | | < 1 | < 1 | < 1 | DRY |
| Ethyl benzene | EP6-06 | 0.5 | 700 | < 1[(b)] | < 1 | < 1 | < 1 |
| | EP6-08 | 0.5 | | < 1 | < 1 | < 1 | < 1 |
| | EP6-09 | 0.5 | | < 1 | < 1 | < 1 | < 1 |
| | K6-01S | 0.5 | | < 1 | < 1 | < 1 | < 1 |
| | K6-19 | 0.5 | | < 1 | < 1 | < 1 | < 1 |
| | K6-36 | 0.5 | | < 1 | < 1 | < 1 | DRY |
| Methylene chloride | EP6-06 | 1 | 5 | < 1 | < 1 | < 1 | < 1 |
| | EP6-08 | 1 | | < 1 | < 1 | < 1 | < 1 |
| | EP6-09 | 1 | | < 1 | < 1 | < 1 | < 1 |
| | K6-01S | 1 | | < 1 | < 1 | < 1 | < 1 |
| | K6-19 | 1 | | < 1 | < 1 | < 1 | < 1 |
| | K6-36 | 1 | | < 1 | < 1 | < 1 | DRY |
| Tetrachloroethene | EP6-06 | 0.5 | 5 | < 1[(b)] | < 1 | < 1 | < 1 |
| (PCE) | EP6-08 | 1.6 | | < 1 | < 1 | < 1 | 1 |
| | EP6-09 | 0.5 | | < 1 | < 1 | < 1 | < 1 |
| | K6-01S | 0.5 | | < 1 | < 1 | < 1 | < 1 |
| | K6-19 | 0.5 | | < 1 | < 1 | < 1 | < 1 |
| | K6-36 | 1.0 | | < 1 | < 1 | < 1 | DRY |
| Toluene | EP6-06 | 0.5 | 150 | < 1[(b)] | < 1 | < 1 | < 1 |
| | EP6-08 | 0.5 | | < 1 | < 1 | < 1 | < 1 |
| | EP6-09 | 0.5 | | < 1 | < 1 | < 1 | < 1 |
| | K6-01S | 0.5 | | < 1 | < 1 | < 1 | < 1 |
| | K6-19 | 0.5 | | < 1 | < 1 | < 1 | < 1 |
| | K6-36 | 0.5 | | < 1 | < 1 | < 1 | DRY |

**Table A-1. Pit 6 post-closure monitoring plan constituents of concern (COCs) detection monitoring wells, SLs, MCLs, and quarterly analytical results for 2006.**

| | | | | Quarter | | | |
|---|---|---|---|---|---|---|---|
| **COC (units)** | **Well** | **SL** | **MCL** | **First** | **Second** | **Third** | **Fourth** |
| 1,1,1-trichloroethane | EP6-06 | 0.5 | 200 | < 1[b] | < 1 | < 1 | < 1 |
| | EP6-08 | 0.5 | | < 1 | < 1 | < 1 | < 1 |
| | EP6-09 | 0.5 | | < 1 | < 1 | < 1 | < 1 |
| | K6-01S | 0.5 | | < 1 | < 1 | < 1 | < 1 |
| | K6-19 | 0.5 | | < 1 | < 1 | < 1 | < 1 |
| | K6-36 | 0.5 | | < 1 | < 1 | < 1 | DRY |
| Trichloroethene (TCE) | EP6-06 | 0.5 | 5 | < 0.5 | < 0.5 | < 0.5 | < 0.5 |
| | EP6-08 | 0.5 | | < 0.5 | < 0.5 | < 0.5 | < 0.5 |
| | EP6-09 | 17 | | 6.4 | 6.6 | 6.6 | 8.5 |
| | K6-01S | 1.5 | | < 0.5 | < 0.5 | < 0.5 | < 0.5 |
| | K6-19 | 13 | | 3.0 | 3.1 | 1.8 | 1.0 |
| | K6-36 | 2.1 | | 0.9 | 0.9 | 0.8 | DRY |
| Xylenes (total) | EP6-06 | 1 | 1750 | < 2 [b] | < 2 | < 2 | < 2 |
| | EP6-08 | 1 | | < 2 | < 2 | < 2 | < 2 |
| | EP6-09 | 1 | | < 2 | < 2 | < 2 | < 2 |
| | K6-01S | 1 | | < 2 | < 2 | < 2 | < 2 |
| | K6-19 | 1 | | < 2 | < 2 | < 2 | < 2 |
| | K6-36 | 1 | | < 2 | < 2 | < 2 | DRY |
| Perchlorate ($\mu$g/L) | EP6-06 | 4.7 | 6 [a] | < 4 | < 4 | < 4 | < 4 |
| | EP6-08 | 4 | | < 4 | < 4 | < 4 | < 4 |
| | EP6-09 | 4 | | 6.7 | < 4 | < 4 | 4.6 |
| | K6-01S | 4 | | < 4 | < 4 | < 4 | < 4 |
| | K6-19 | 27.5 | | < 4 | < 4 | < 4 | < 4 |
| | K6-36 | 14.4 | | < 4 | < 4 | < 4 | DRY |

[a] California state action level.

[b] The analytical laboratory reported incorrect reporting limits, LLNL is attempting to correct this.

**Table A-2. Pit 6 detection monitoring quarterly ground water physical parameters for 2006.**

| | | | Parameters | | | | |
|---|---|---|---|---|---|---|---|
| **Detection well** | **Quarter 2006** | **Date sampled** | **GWE [a] (ft)** | **Temp. (°C)** | **pH (pH units)** | **Sp. cond. (μmho/cm)** | **TDS[b] (mg/L)** |
| EP6-06 | 1 | 20-Jan-06 | 661.21 | 20.4 | 7.85 | 1297 | 860 |
| | 2 | 26-Apr-06 | 661.56 | 21.7 | 7.37 | 1285 | 840 |
| | 3 | 7-Aug-06 | 661.39 | 21.5 | 7.63 | 1306 | 840 |
| | 4 | 25-Oct-06 | 661.18 | 21.5 | 7.54 | 1300 | 840 |
| EP6-08 | 1 | 20-Jan-06 | 659.69 | 19.8 | 7.72 | 1095 | 750 |
| | 2 | 26-Apr-06 | 661.84 | 21.1 | 7.36 | 1089 | 700 |
| | 3 | 18-Jul-06 | 656.45 | 22.7 | 7.46 | 1108 | 730 |
| | 4 | 30-Oct-06 | 651.61 | 22.2 | 7.2 | 1119 | 770 |
| EP6-09 | 1 | 3-Jan-06 | 664.59 | 20.6 | 7.84 | 1500 | 980 |
| | 2 | 26-Apr-06 | 661.84 | 21.1 | 7.36 | 1089 | 700 |
| | 3 | 19-Jul-06 | 664.50 | 21.7 | 7.66 | 1513 | 1000 |
| | 4 | 30-Oct-06 | 664.58 | 20.7 | 7.53 | 1531 | 1000 |
| K6-01S | 1 | 3-Jan-06 | 664.48 | 21.2 | 7.33 | 4082 | 3200 |
| | 2 | 8-May-06 | 664.35 | 21.6 | 7.1 | 397 [c] | 3100 |
| | 3 | 19-Jul-06 | 664.55 | 21.5 | 7.01 | 4169 | 3400 |
| | 4 | 30-Oct-06 | 664.52 | 21 | 6.89 | 4175 | 3500 |
| K6-19 | 1 | 20-Jan-06 | 663.88 | 20.1 | 7.72 | 1169 | 760 |
| | 2 | 3-May-06 | 663.80 | 22.2 | 7.64 | 1173 | 760 |
| | 3 | 18-Jul-06 | 663.86 | 21.1 | 7.69 | 1158 | 750 |
| | 4 | 25-Oct-06 | 663.82 | 22.4 | 7.58 | 1173 | 730 |
| K6-36 | 1 | 20-Jan-06 | 659.45 | 20.7 | 7.88 | 1092 | 730 |
| | 2 | 26-Apr-06 | 661.95 | 21.6 | 7.37 | 1070 | 660 |
| | 3 | 7-Aug-06 | 656.00 | 22.5 | 7.71 | 1089 | 710 |
| | 4 | 25-Oct-06 | Dry | Dry | Dry | Dry | Dry |

(a) Ground water elevation (water table elevation in feet above mean sea level).

(b) Total dissolved solids.

(c) Value appears to be a laboratory error.

# Appendix B

# Tables of Ground Water Measurements

# for Corrective Action Monitoring Wells

**Table B-1. Water elevation measurements in Pit 6 ground water monitoring wells, fourth quarter 2006.**

| Well | Date sampled | Ground water elevation (ft. above MSL) |
|---|---|---|
| BC6-10 | 2-Oct-06 | 659.60 |
| BC6-13 | 2-Oct-06 | DRY |
| CARNRW1 | 2-Oct-06 | 644.64 |
| CARNRW1 | 2-Oct-06 | 644.64 |
| CARNRW2 | 2-Oct-06 | NM/PS |
| CARNRW3 | 2-Oct-06 | 666.87 |
| CARNRW4 | 2-Oct-06 | 639.50 |
| EP6-06 | 25-Oct-06 | 661.18 |
| EP6-06 | 2-Oct-06 | 661.21 |
| EP6-07 | 2-Oct-06 | 655.05 |
| EP6-08 | 2-Oct-06 | 651.61 |
| EP6-08 | 30-Oct-06 | 651.61 |
| EP6-09 | 2-Oct-06 | 664.58 |
| EP6-09 | 30-Oct-06 | 664.58 |
| K6-01 | 2-Oct-06 | 664.64 |
| K6-01S | 30-Oct-06 | 664.52 |
| K6-01S | 2-Oct-06 | 664.52 |
| K6-03 | 2-Oct-06 | 656.43 |
| K6-04 | 2-Oct-06 | 657.27 |
| K6-14 | 2-Oct-06 | 658.34 |
| K6-15 | 2-Oct-06 | DRY |
| K6-16 | 2-Oct-06 | 660.83 |
| K6-17 | 2-Oct-06 | 655.71 |
| K6-18 | 2-Oct-06 | 660.01 |
| K6-19 | 2-Oct-06 | 663.89 |
| K6-19 | 25-Oct-06 | 663.82 |
| K6-21 | 2-Oct-06 | DRY |
| K6-22 | 2-Oct-06 | 647.53 |
| K6-23 | 2-Oct-06 | 656.99 |
| K6-24 | 2-Oct-06 | 659.80 |
| K6-25 | 2-Oct-06 | 660.66 |
| K6-26 | 2-Oct-06 | 659.94 |
| K6-27 | 2-Oct-06 | 658.34 |
| K6-32 | 2-Oct-06 | 657.97 |
| K6-33 | 2-Oct-06 | 652.03 |
| K6-34 | 2-Oct-06 | 643.33 |
| K6-35 | 2-Oct-06 | 658.05 |
| K6-36 | 2-Oct-06 | DRY/CB |
| W-33C-01 | 23-Oct-06 | 640.21 |
| W-34-01 | 23-Oct-06 | NM/UC |
| W-34-02 | 23-Oct-06 | NM/UC |
| W-PIT6-1819 | 2-Oct-06 | 642.17 |

**Table B-2. Volatile organic compounds deteced in Pit 6 ground water samples, fourth quarter 2006.**

| VOCs detected | Well | Date sampled | Type | Result (µg/L) |
|---|---|---|---|---|
| ***VOCs (EPA 601 or EPA 624)*** | | | | |
| 1,2-Dichloroethene (total) | K6-01S | 30-Oct-06 | RTN | 1.7 |
| Trichloroethene | EP6-09 | 30-Oct-06 | RTN | 8.5 |
| Trichloroethene | K6-19 | 25-Oct-06 | RTN | 1 |
| Tetrachloroethene | EP6-08 | 30-Oct-06 | RTN | 1 |
| cis-1,2-Dichloroethene | K6-01S | 30-Oct-06 | RTN | 1.7 |

**Table B-3. Tritium activity measurements in Pit 6 ground water samples, fourth quarter 2006.**

| Well | Date sampled | Activity (pCi/L) | Activity (Bq/L) |
|---|---|---|---|
| CARNRW1 | 31-Oct-06 | < 100 | < 3.7 |
| CARNRW1 | 4-Dec-06 | < 100 | < 3.7 |
| CARNRW1 | 2-Oct-06 | < 200 | < 7.4 |
| CARNRW1 | 31-Oct-06 | < 200 | < 7.4 |
| CARNRW1 | 4-Dec-06 | < 200 | < 7.4 |
| CARNRW1 | 2-Oct-06 | < 100 | < 3.7 |
| CARNRW2 | 31-Oct-06 | < 100 | < 3.7 |
| CARNRW2 | 4-Dec-06 | < 100 | < 3.7 |
| CARNRW2 | 2-Oct-06 | < 200 | < 7.4 |
| CARNRW2 | 31-Oct-06 | < 200 | < 7.4 |
| CARNRW2 | 4-Dec-06 | < 200 | < 7.4 |
| CARNRW2 | 2-Oct-06 | < 100 | < 3.7 |
| CARNRW3 | 31-Oct-06 | < 100 | < 3.7 |
| CARNRW3 | 4-Dec-06 | < 100 | < 3.7 |
| CARNRW3 | 2-Oct-06 | < 200 | < 7.4 |
| CARNRW3 | 31-Oct-06 | < 200 | < 7.4 |
| CARNRW3 | 4-Dec-06 | < 200 | < 7.4 |
| CARNRW3 | 2-Oct-06 | < 100 | < 3.7 |
| CARNRW4 | 2-Oct-06 | < 100 | < 3.7 |
| CARNRW4 | 31-Oct-06 | < 200 | < 7.4 |
| CARNRW4 | 2-Oct-06 | < 200 | < 7.4 |
| CARNRW4 | 4-Dec-06 | < 100 | < 3.7 |
| CARNRW4 | 31-Oct-06 | < 100 | < 3.7 |
| CARNRW4 | 4-Dec-06 | < 200 | < 7.4 |
| EP6-06 | 25-Oct-06 | < 100 | < 3.7 |
| EP6-08 | 30-Oct-06 | < 100 | < 3.7 |
| EP6-09 | 30-Oct-06 | < 100 | < 3.7 |
| K6-01S | 30-Oct-06 | 128 | 4.736 |
| K6-17 | 10-Oct-06 | < 200 | < 7.4 |
| K6-17 | 10-Oct-06 | < 100 | < 3.7 |
| K6-19 | 25-Oct-06 | 224 | 8.288 |
| K6-22 | 10-Oct-06 | < 100 | < 3.7 |
| K6-34 | 10-Oct-06 | < 100 | < 3.7 |
| W-PIT6-1819 | 10-Oct-06 | 128 | 4.736 |

**Table B-4. Perchlorate and nitrate concentrations in Pit 6 ground water samples, fourth quarter 2006.**

| Well | Date sampled | Perchlorate ($\mu$g/L) | Nitrate (as $NO_3$) (mg/L) |
|---|---|---|---|
| CARNRW1 | 2-Oct-06 | < 4 | < 0.1 |
| CARNRW1 | 2-Oct-06 | < 4 | < 0.5 |
| CARNRW1 | 31-Oct-06 | < 4 | < 0.1 |
| CARNRW1 | 31-Oct-06 | < 4 | < 0.5 |
| CARNRW1 | 4-Dec-06 | < 4 | < 0.1 |
| CARNRW1 | 4-Dec-06 | < 4 | < 0.5 |
| CARNRW2 | 2-Oct-06 | < 4 | < 0.1 |
| CARNRW2 | 2-Oct-06 | < 4 | < 0.5 |
| CARNRW2 | 31-Oct-06 | < 4 | < 0.1 |
| CARNRW2 | 31-Oct-06 | < 4 | < 0.5 |
| CARNRW2 | 4-Dec-06 | < 4 | < 0.1 |
| CARNRW2 | 4-Dec-06 | < 4 | < 0.5 |
| CARNRW3 | 2-Oct-06 | < 4 | < 0.1 |
| CARNRW3 | 2-Oct-06 | < 4 | < 0.5 |
| CARNRW3 | 31-Oct-06 | < 4 | 0.37 |
| CARNRW3 | 31-Oct-06 | < 4 | < 0.5 |
| CARNRW3 | 4-Dec-06 | < 4 | < 0.1 |
| CARNRW3 | 4-Dec-06 | < 4 | < 0.5 |
| CARNRW4 | 2-Oct-06 | < 4 | < 0.1 |
| CARNRW4 | 2-Oct-06 | < 4 | < 0.5 |
| CARNRW4 | 31-Oct-06 | < 4 | < 0.1 |
| CARNRW4 | 31-Oct-06 | < 4 | < 0.5 |
| CARNRW4 | 4-Dec-06 | < 4 | < 0.1 |
| CARNRW4 | 4-Dec-06 | < 4 | < 0.5 |
| EP6-06 | 25-Oct-06 | < 4 | < 0.5 |
| EP6-08 | 30-Oct-06 | < 4 | < 0.5 |
| EP6-09 | 30-Oct-06 | 4.6 | 5.8 |
| K6-01S | 30-Oct-06 | < 4 | < 2.5 |
| K6-19 | 25-Oct-06 | < 4 | < 0.5 |

**Table B-5. Pit 6 monitoring locations, monitoring functions, associated monitoring programs, COCs, monitoring frequencies, and fourth quarter 2006 sampling summary.**

| Monitoring location | Monitoring function | Monitoring program | COCs[(a)] (sampling frequency) | COCs analyzed | Reason(s), if not completed |
|---|---|---|---|---|---|
| K6-17 | guard well | CAMP | P (Q), S (SA) | P | |
| K6-22 | guard well | CAMP | P (Q), S (SA) | P | |
| K6-34 | guard well | CAMP | P (Q), S (SA) | P | |
| W-PIT6-1819 | guard well | CAMP | P (Q), S (SA) | P | |
| SPRING7 | plume tracking spring | CAMP | P (SA), S (A) | none | not scheduled |
| SPRING15 | plume tracking spring | CAMP | P (SA), S (A) | none | not scheduled |
| BC6-10 | plume tracking well | CAMP | P (SA), S (A) | none | not scheduled |
| BC6-13 | plume tracking well | CAMP | P (SA), S (A) | none | not scheduled |
| EP6-07 | plume tracking well | CAMP | P (SA), S (A) | none | not scheduled |
| K6-01 | plume tracking well | CAMP | P (SA), S (A) | none | not scheduled |
| K6-03 | plume tracking well | CAMP | P (SA), S (A) | none | not scheduled |
| K6-04 | plume tracking well | CAMP | P (SA), S (A) | none | not scheduled |
| K6-14 | plume tracking well | CAMP | P (SA), S (A) | none | not scheduled |
| K6-15 | plume tracking well | CAMP | P (SA), S (A) | none | not scheduled |
| K6-16 | plume tracking well | CAMP | P (SA), S (A) | none | not scheduled |
| K6-18 | plume tracking well | CAMP | P (SA), S (A) | none | not scheduled |
| K6-21 | plume tracking well | CAMP | P (SA), S (A) | none | not scheduled |
| K6-23 | plume tracking well | CAMP | P (SA), S (A) | none | not scheduled |
| K6-24 | plume tracking well | CAMP | P (SA), S (A) | none | not scheduled |
| K6-25 | plume tracking well | CAMP | P (SA), S (A) | none | not scheduled |
| K6-26 | plume tracking well | CAMP | P (SA), S (A) | none | not scheduled |
| K6-27 | plume tracking well | CAMP | P (SA), S (A) | none | not scheduled |
| K6-32 | plume tracking well | CAMP | P (SA), S (A) | none | not scheduled |
| K6-33 | plume tracking well | CAMP | P (SA), S (A) | none | not scheduled |
| K6-35 | plume tracking well | CAMP | P (SA), S (A) | none | not scheduled |
| W-33C-01 | plume tracking well | CAMP | P (SA), S (A) | none | not scheduled |
| EP6-06 | release detection well | DMP | All (Q) | All | |
| EP6-08 | release detection well | DMP | All (Q) | All | |
| EP6-09 | release detection well | DMP | All (Q) | All | |
| K6-01S | release detection well | DMP | All (Q) | All | |
| K6-19 | release detection well | DMP | All (Q) | All | |
| K6-36 | release detection well | DMP | All (Q) | All | |
| CARNRW1 | water supply well | CAMP | P (M), S (M) | P,S | |
| CARNRW2 | water supply well | CAMP | P (M), S (M) | P,S | |
| CARNRW3 | water supply well | CAMP | P (M), S (M) | P,S | |
| CARNRW4 | water supply well | CAMP | P (M), S (M) | P,S | |

[(a)] P means the primary COCs tritium and VOCs. S means the secondary COCs perchlorate and nitrate. All means all DMP COCs (see **Table C-1** for a list). (M) means sampled monthly. (Q) means sampled quarterly. (SA) means sampled semiannually (done first and third quarters of year). (A) means sampled annually (done first quarter of year).

# Appendix C

# Statistical Methods for Detection Monitoring

# Appendix C

## Statistical Methods for Detection Monitoring

Monitoring and reporting provisions of the CERCLA closure and post-closure plan for the Pit 6 landfill require the use of statistical methods from the *California Code of Regulations* (CCR), Title 23, Division 3, Chapter 15, Section 2550.7 (Ferry *et al*. 1998).

We use statistically determined limits of concentration (SLs) to detect potential releases of constituents of concern (COCs) to ground water from solid wastes contained in the Pit 6 landfill. We employ two statistical methods, prediction intervals (PIs) and control charts (CCs), to generate SLs. Both methods are sensitive to COC concentration increases. Both methods are cost-effective, requiring only one measurement of a COC per quarter per monitoring well.

We prefer the PI method when COC concentrations in ground water are similar upgradient and downgradient from the monitored unit. We use parametric PI methods when the upgradient COC concentration data are all above the detection limit and the data are approximately normally distributed. We may use parametric methods on log-transformed data, if the transformed data follow a normal distribution. Nonparametric PI methods are more effective when the data cannot be transformed to a normal distribution, or when they contain nondetections.

When the concentration of a COC is spatially variable in the vicinity of a monitored unit, we develop a control chart for each downgradient monitoring well. The control chart compares each new quarterly COC measurement with its concentration history for that well.

Wherever sufficient historical detections exist, we calculate an SL such that any future measurement has approximately a 1-in-100 chance of exceeding the SL, when no change in concentration has actually occurred. This yields a statistical test with a significance level of approximately 0.01. Where historical detections exist, but nondetections constitute part of the data, we set the SL equal to the highest concentration measured. If historical analyses of a COC show all nondetections, then we set the SL equal to the analytical reporting limit (RL). When a routine COC measurement exceeds an SL, we perform two discrete

retests. This method of data verification is in accordance with CCR Title 23, Chapter 15, Section 2550.7.

**Constituents of Concern**

COCs were identified for monitoring in the ground water at the Pit 6 landfill prior to its closure (Ferry *et al.* 1998). COCs, as defined by CCR Title 22, Chapter 15, are waste constituents, their reaction products, or hazardous constituents that are reasonably expected to be in or derived from waste buried in Pit 6. The current COCs for Pit 6 are listed in **Table C-1** below.

**Table C-1. Pit 6 COCs, typical analytical reporting limit (RL), concentration limit (CL)[a] and statistical limit (SL) for each of the six detection monitoring wells.**

| Constituent of concern (COC) | Typical analytical RL (units) | Well EP6-06 CL; SL | Well EP6-08 CL; SL | Well EP6-09 CL; SL | Well K6-01S CL; SL | Well K6-19 CL; SL | Well K6-36 CL; SL |
|---|---|---|---|---|---|---|---|
| **1,1,1-TCA** | 0.5 µg/L | <RL; RL | <RL; RL | <RL; RL | <RL; RL | <RL; RL | <RL; RL |
| **1,2-DCA** | 0.5 µg/L | <RL; RL | <RL; RL | <RL; RL | <RL; RL | <RL; RL | <RL; RL |
| **Cis-1,2-DCE** | 0.5 µg/L | <RL; RL | <RL; RL | <RL; RL | 5.4; 7.0 | <RL; RL | <RL; RL |
| **Chloroform** | 0.5 µg/L | <RL; RL | 0.1; 1.0 | <RL; RL | <RL; RL | 0.2; 1.5 | <RL; RL |
| **Methylene chloride** | 0.5 µg/L | <RL; RL | <RL; RL | <RL; RL | <RL; RL | <RL; RL | <RL; RL |
| **PCE** | 0.5 µg/L | <RL; RL | 0.4; 1.6 | <RL; RL | <RL; RL | <RL; RL | 0.5; 1.0 |
| **TCE** | 0.5 µg/L | <RL; RL | <RL; RL | 14; 17 | 1.1; 1.5 | 8.2; 13 | 0.8; 2.1 |
| **Benzene** | 0.5 µg/L | <RL; RL | <RL; RL | <RL; RL | <RL; RL | <RL; RL | <RL; RL |
| **Ethylbenzene** | 0.5 µg/L | <RL; RL | <RL; RL | <RL; RL | <RL; RL | <RL; RL | <RL; RL |
| **Toluene** | 0.5 µg/L | <RL; RL | <RL; RL | <RL; RL | <RL; RL | <RL; RL | <RL; RL |
| **Total xylenes** | 1.0 µg/L | <RL; RL | <RL; RL | <RL; RL | <RL; RL | <RL; RL | <RL; RL |
| **Beryllium** | 0.5 µg/L | <RL; RL | <RL; RL | <RL; RL | <RL; RL | <RL; RL | <RL; RL |
| **Mercury** | 0.2 µg/L | <RL; RL | <RL; RL | <RL; RL | <RL; RL | <RL; RL | <RL; RL |
| **Carbon disulfide** | 5.0 µg/L | <RL; RL | <RL; RL | <RL; RL | <RL; RL | <RL; RL | <RL; RL |
| **Perchlorate** | 4.0 µg/L | <RL; RL | <RL; RL | <RL; RL | <RL; RL | 10.2; 27.5 | 5.3; 14.4 |
| **Tritium** | 100 pCi/L | RL; RL | <RL; RL | <RL; RL | <RL; RL | <RL; RL | 2060; 2390 |
| **Uranium (total)** | 0.5 pCi/L | 1.9; 3.6 | 1.2; 1.5 | 2.1; 3.7 | 6.6; 27 | 3.2; 7.2 | 0.5; 1.4 |
| **Gross alpha [b]** | 2 pCi/L | 2.7; 7.7 | 0.9; 4.0 | 1.0; 4.9 | 7.0; 26 | 2.0; 9.2 | <RL; RL |
| **Gross beta [b]** | 2 pCi/L | 8.6; 21 | 8.6; 21 | 8.6; 21 | 14; 58 | 8.6; 21 | 9.8; 26 |

[a] CL (concentration limit) is equivalent to the background concentration of a COC.

[b] Gross alpha and gross beta are surrogates for $^{125}Sb$, $^{137}Cs$, $^{60}Co$, $^{22}Na$, $^{90}Sr$, $^{204}Tl$, and $^{232}Th$.

Chlorinated VOCs (including TCE, PCE, 1,2-DCA, 1,1,1-TCA, methylene chloride, chloroform, benzene, toluene, ethylbenzene, and total xylenes) were detected historically in ground water and/or in soil adjacent to Pit 6. These VOCs are COCs.

Beryllium and mercury are COCs because they are listed in the waste disposal records for Pit 6.

Nine radionuclide COCs are associated with waste buried in Pit 6. They are $^{125}Sb$, $^{137}Cs$, $^{60}Co$, $^{22}Na$, $^{90}Sr$, $^{204}Tl$, $^{232}Th$, $^{238}U$, and tritium. Gross alpha and gross beta radioactivity are used as surrogates for seven of these nuclides, but not for uranium and tritium, which are measured separately (**Table C-1**).

A minor tritium release occurred prior to closure of Pit 6 and is the object of a continuing LLNL CERCLA investigation. The detection monitoring well BC6-12 was destroyed during year 2000, because it was screened across two water-bearing zones and could have provided a conduit for tritium in the shallower zone to contaminate ground water in the deeper zone. Well BC6-12 was replaced by well K6-36, which was constructed adjacent to it. Well K6-36 is screened only in the shallow water-bearing zone. Our calculated COC SLs for replacement well K6-36 are shown (**Table C-1)**.

A post-closure LLNL CERCLA study detected perchlorate in ground water downgradient of Pit 6. Consequently, perchlorate was added to the COC list and we have calculated SLs for this chemical (**Table C-1**).

Pesticides were not detected over an 18-month period (6 quarterly sampling events) following pit closure and were removed from the COC list.

Phthalates were not designated as COCs, because they were rarely detected prior to pit closure. However, since post-closure monitoring began in 1998, we have detected bis(2-ethylhexyl)phthalate (also known as di[2-ethylhexyl]phthalate, or DEHP) in ground water both upgradient and downgradient from Pit 6.

**Table C-2** lists COCs that have indicated statistically significant evidence of release to ground water since post-closure monitoring began in 1998. **Table C-2** also lists the date of our 7-day letter notification to CVRWQCB and the status of any additional investigation of the COC. Note that 1,2-DCA has not been detected since 1998.

**Table C-2. Pit 6 COCs showing statistical evidence of post-closure release.**

| COC | Date of 7-day letter report | Status of release investigation |
|---|---|---|
| 1,2-DCA | 10/13/98[a] | Transferred to ERD[b] |
| Perchlorate | 11/08/02[c] | Retests did not confirm a release |
| Uranium | 05/10/04[d] | Retest indicates a natural source |

[a] Galles, H. L., to S. Timm (1998), Letter: *Statistically Significant Evidence for a Release of 1,2-Dichloroethane from Pit 6* (WGMG98:282, October 13, 1998).

[b] LLNL Environmental Restoration Division.

[c] Raber, E., to T. Park, K. Setian, and S. Timm (2002), Letter*: Statistically Significant Evidence for a Release of Perchlorate from Lawrence Livermore National Laboratory Experimental Test Site (Site 300) Pit 6* (WGMG02-182, November 8, 2002).

[d] Raber, E., to T. Park, K. Setian, and S. Timm (2004), Letter: *Statistically Significant Evidence for a Release of Uranium from Lawrence Livermore National Laboratory Experimental Test Site (Site 300) Pit 6* (WGMG04-055, May 10, 2004).

# Appendix D

# Changes in Monitoring Programs or Methods

# Appendix D

## Changes in Monitoring Programs or Methods

LLNL implemented a compliance monitoring program during the second quarter of 1998 for the CERCLA-closed Pit 6 landfill at Site 300. The program is described in detail in Ferry *et al.* 1998.

During 2000, two new monitoring wells, designated K6-35 and K6-36, replaced monitoring wells BC6-11 and BC6-12, which were destroyed by grouting. Well K6-36, which is screened in the first (shallower) of two water-bearing zones, replaced well BC6-12 for release detection. Well K6-35, screened in the next deeper water-bearing zone, is used for corrective-action assessment.

By request of the CVRWQCB, we added perchlorate to the list of Pit 6 COCs during the third quarter of 2000.

By request of the CVRWQCB, since the third quarter of 2000, we have provided a table of information (**Table B-5)** that lists the Pit 6 CERCLA monitoring wells, their monitoring program assignments, their sampling frequencies, the COCs they monitor, and a reason if they were not sampled during the reported quarter.

During 2001, quarterly tritium monitoring was expanded to include CERCLA well K6-33 and the private, off-site, water supply wells designated CARNRW1 and CARNRW2. During 2002 a new CERCLA guard well was completed downgradient from Pit 6 adjacent to the Site 300 boundary. This well is identified as W-PIT6-1819.

Beginning January 1, 2003 the CAMP sampling schedule and COCs have changed as described in the *Compliance Monitoring Plan/Contingency Plan for Interim Remedies at Lawrence Livermore National Laboratory Site 300* (Ferry, *et al.* 2002). An expanded set of CAMP wells and springs will be sampled semiannually for tritium and VOCs, and annually for nitrate and perchlorate, while DMP well monitoring remains essentially unchanged. However, upgradient wells K6-03, K6-04, K6-15, and K6-32, which were formerly sampled quarterly for all the DMP COCs listed in **Table C-1**, are now designated to be CAMP plume-tracking wells and are sampled semiannually for tritium and VOCs and annually for nitrate and perchlorate only. As of fourth quarter 2004 VOCs have been reported as Total VOCs (TVOCs) to be consistent with other reports.

# Appendix E

# Quality Assurance Sample Results

**Table E-1. Quality assurance samples from Pit 6 during 2006.**

| | | First Quarter | | | Second Quarter | | | Third Quarter | | | Fourth Quarter | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Constituent | units | EP6-09 routine | EP6-09 duplicate | PIT6 field blank | K6-19 routine | K6-19 duplicate | PIT6 field blank | K6-01S routine | K6-01S duplicate | PIT6 field blank | K6-36 routine | K6-36 duplicate | PIT6 field blank |
| Total dissolved solids (TDS) | mg/L | 980 | 950 | < 6.7 | 760 | 700 | < 6.7 | 3400 | 3200 | 6.7 | **Well** | **Well** | 13 |
| Beryllium | ug/L | < 0.5 | < 0.5 | < 0.5 | < 0.5 | < 0.5 | < 0.5 | < 0.5 | < 0.5 | < 0.5 | **Dry** | **Dry** | < 0.5 |
| Mercury | ug/L | < 0.2 | < 0.2 | < 0.2 | < 0.2 | < 0.2 | < 0.2 | < 0.2 | < 0.2 | < 0.2 | | | < 0.2 |
| Nitrate (as NO3) | mg/L | 3.4 | 3.4 | < 0.5 | < 0.5 | < 0.5 | < 0.5 | < 1 | < 1 | < 0.5 | | | < 0.5 |
| Perchlorate | ug/L | 6.7 | 4.2 | < 4 | < 4 | < 4 | < 4 | < 4 | < 4 | < 4 | | | < 4 |
| 1,1,1-Trichloroethane | ug/L | < 1 | < 1 | < 1 | < 1 | < 1 | < 1 | < 1 | < 1 | < 1 | | | < 1 |
| 1,1,2,2-Tetrachloroethane | ug/L | < 1 | < 1 | < 1 | < 1 | < 1 | < 1 | < 1 | < 1 | < 1 | | | < 1 |
| 1,1,2-Trichloroethane | ug/L | < 1 | < 1 | < 1 | < 1 | < 1 | < 1 | < 1 | < 1 | < 1 | | | < 1 |
| 1,1-Dichloroethane | ug/L | < 1 | < 1 | < 1 | < 1 | < 1 | < 1 | < 1 | < 1 | < 1 | | | < 1 |
| 1,1-Dichloroethene | ug/L | < 1 | < 1 | < 1 | < 1 | < 1 | < 1 | < 1 | < 1 | < 1 | | | < 1 |
| 1,2-Dichlorobenzene | ug/L | < 1 | < 1 | < 1 | < 1 | < 1 | < 1 | < 1 | < 1 | < 1 | | | < 1 |
| 1,2-Dichloroethane | ug/L | < 1 | < 1 | < 1 | < 1 | < 1 | < 1 | < 1 | < 1 | < 1 | | | < 1 |
| 1,2-Dichloroethene (total) | ug/L | < 1 | < 1 | < 1 | < 1 | < 1 | < 1 | 2.2 | 2.3 | < 1 | | | < 1 |
| 1,2-Dichloropropane | ug/L | < 0.5 | < 0.5 | < 0.5 | < 0.5 | < 0.5 | < 0.5 | < 0.5 | < 0.5 | < 0.5 | | | < 0.5 |
| 1,3-Dichlorobenzene | ug/L | < 1 | < 1 | < 1 | < 1 | < 1 | < 1 | < 1 | < 1 | < 1 | | | < 1 |
| 1,4-Dichlorobenzene | ug/L | < 1 | < 1 | < 1 | < 1 | < 1 | < 1 | < 1 | < 1 | < 1 | | | < 1 |
| cis-1,2-Dichloroethene | ug/L | < 1 | < 1 | < 1 | < 1 | < 1 | < 1 | 2.2 | 2.3 | < 1 | | | < 1 |
| cis-1,3-Dichloropropene | ug/L | < 1 | < 1 | < 1 | < 1 | < 1 | < 1 | < 1 | < 1 | < 1 | | | < 1 |
| 2-Butanone | ug/L | < 20 | < 20 | < 20 | < 20 | < 20 | < 20 | < 20 | < 20 | < 20 | | | < 20 |
| 2-Chloroethylvinylether | ug/L | < 20 | < 20 | < 20 | < 20 | < 20 | < 20 | < 20 | < 20 | < 20 | | | < 20 |
| 2-Hexanone | ug/L | < 20 | < 20 | < 20 | < 20 | < 20 | < 20 | < 20 | < 20 | < 20 | | | < 20 |
| 4-Methyl-2-pentanone | ug/L | < 20 | < 20 | < 20 | < 20 | < 20 | < 20 | < 20 | < 20 | < 20 | | | < 20 |
| Acetone | ug/L | < 10 | < 10 | < 10 | < 10 | < 10 | < 10 | < 10 | < 10 | 22 | | | < 10 |
| Benzene | ug/L | < 1 | < 1 | < 1 | < 1 | < 1 | < 1 | < 1 | < 1 | < 1 | | | < 1 |
| Bromodichloromethane | ug/L | < 1 | < 1 | < 1 | < 1 | < 1 | < 1 | < 1 | < 1 | < 1 | | | < 1 |
| Bromoform | ug/L | < 1 | < 1 | < 1 | < 1 | < 1 | < 1 | < 1 | < 1 | < 1 | | | < 1 |
| Bromomethane | ug/L | < 2 | < 2 | < 2 | < 2 | < 2 | < 2 | < 2 | < 2 | < 2 | | | < 2 |
| Carbon disulfide | ug/L | < 1 | < 1 | < 1 | < 1 | < 1 | < 1 | < 1 | < 1 | < 1 | | | < 1 |
| Carbon tetrachloride | ug/L | < 1 | < 1 | < 1 | < 1 | < 1 | < 1 | < 1 | < 1 | < 1 | | | < 1 |
| Chlorobenzene | ug/L | < 1 | < 1 | < 1 | < 1 | < 1 | < 1 | < 1 | < 1 | < 1 | | | < 1 |
| Chloroethane | ug/L | < 2 | < 2 | < 2 | < 2 | < 2 | < 2 | < 2 | < 2 | < 2 | | | < 2 |
| Chloroform | ug/L | < 1 | < 1 | < 1 | < 1 | < 1 | 3.2 | < 1 | < 1 | < 1 | | | < 1 |
| Chloromethane | ug/L | < 2 | < 2 | < 2 | < 2 | < 2 | < 2 | < 2 | < 2 | < 2 | | | < 2 |
| Dibromochloromethane | ug/L | < 1 | < 1 | < 1 | < 1 | < 1 | < 1 | < 1 | < 1 | < 1 | | | < 1 |
| Dibromomethane | ug/L | < 1 | < 1 | < 1 | < 1 | < 1 | < 1 | < 1 | < 1 | < 1 | | | < 1 |
| Dichlorodifluoromethane | ug/L | < 2 | < 2 | < 2 | < 2 | < 2 | < 2 | < 2 | < 2 | < 2 | | | < 2 |
| Ethylbenzene | ug/L | < 1 | < 1 | < 1 | < 1 | < 1 | < 1 | < 1 | < 1 | < 1 | | | < 1 |
| Freon 113 | ug/L | < 1 | < 1 | < 1 | < 1 | < 1 | < 1 | < 1 | < 1 | < 1 | | | < 1 |
| Methylene chloride | ug/L | < 1 | < 1 | < 1 | < 1 | < 1 | < 1 | < 1 | < 1 | < 1 | | | < 1 |

**Table E-1. Quality assurance samples from Pit 6 during 2006.**

| | | First Quarter | | | Second Quarter | | | Third Quarter | | | Fourth Quarter | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | EP6-09 | EP6-09 | PIT6 | K6-19 | K6-19 | PIT6 | K6-01S | K6-01S | PIT6 | K6-36 | K6-36 | PIT6 |
| Constituent | units | routine | duplicate | field blank | routine | duplicate | field blank | routine | duplicate | field blank | routine | duplicate | field blank |
| Styrene | ug/L | < 1 | < 1 | < 1 | < 1 | < 1 | < 1 | < 1 | < 1 | < 1 | | | < 1 |
| Tetrachloroethene | ug/L | < 1 | < 1 | < 1 | < 1 | < 1 | < 1 | < 1 | < 1 | < 1 | | | < 1 |
| Toluene | ug/L | < 1 | < 1 | < 1 | < 1 | < 1 | < 1 | < 1 | < 1 | < 1 | | | < 1 |
| Total xylene isomers | ug/L | < 2 | < 2 | < 2 | < 2 | < 2 | < 2 | < 2 | < 2 | < 2 | | | < 2 |
| trans-1,2-Dichloroethene | ug/L | < 1 | < 1 | < 1 | < 1 | < 1 | < 1 | < 1 | < 1 | < 1 | | | < 1 |
| trans-1,3-Dichloropropene | ug/L | < 1 | < 1 | < 1 | < 1 | < 1 | < 1 | < 1 | < 1 | < 1 | | | < 1 |
| Trichloroethene | ug/L | 6.4 | 6.5 | < 0.5 | 3.1 | 3.2 | < 0.5 | < 0.5 | < 0.5 | < 0.5 | | | < 0.5 |
| Trichlorofluoromethane | ug/L | < 1 | < 1 | < 1 | < 1 | < 1 | < 1 | < 1 | < 1 | < 1 | | | < 1 |
| Vinyl chloride | ug/L | < 1 | < 1 | < 1 | < 1 | < 1 | < 1 | < 1 | < 1 | < 1 | | | < 1 |
| Tritium | Bq/L | 29.4 ± 4.1 | 1.0 ± 2.1 | -1.7 ± 2.1 | 12.2 ± 2.6 | 11.1 ± 2.5 | -2.9 ± 2.1 | 8.7 ± 2.4 | 9.0 ± 2.3 | 0.3 ± 2.1 | | | 0.1 ± 2.0 |
| Gross alpha | Bq/L | 0.018 ± 0.056 | 0.016 ± 0.041 | -0.008 ± 0.007 | 0.094 ± 0.078 | -0.013 ± 0.078 | -0.013 ± 0.012 | -1.032 ± 0.481 | -0.188 ± 0.226 | -0.007 ± 0.009 | | | -0.025 ± 0.015 |
| Gross beta | Bq/L | 0.451 ± 0.089 | 0.429 ± 0.081 | -0.009 ± 0.022 | 0.339 ± 0.078 | 0.343 ± 0.089 | 0.004 ± 0.021 | 0.644 ± 0.444 | 0.640 ± 0.185 | 0.016 ± 0.022 | | | 0.002 ± 0.021 |
| Uranium (total) | Bq/L | 0.080 ± 0.008 | 0.089 ± 0.009 | 0.001 ± 0.001 | 0.097 ± 0.010 | 0.083 ± 0.009 | 0.000 ± 0.001 | 0.144 ± 0.013 | 0.132 ± 0.012 | 0.002 ± 0.001 | | | 0.001 ± 0.001 |


**Operations & Regulatory Affairs Division, Lawrence Livermore National Laboratory**
**University of California, P.O. Box 808, L-627, Livermore, California 94551**